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**RIGHTHANDEDNESS AND
LEFTHANDEDNESS**

Righthandedness and Lefthandedness

WITH

CHAPTERS TREATING OF THE WRITING
POSTURE, THE RULE OF THE ROAD, ETC.

BY

GEORGE M. GOULD, M.D.



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INTRODUCTION

THE theories that have been advanced as to the origin of righthandedness and lefthandedness are:

1. A natural provision. (Sir Charles Bell, and others.)

2. The left-sided location of the heart. (Referred to by Wilson.)

3. A greater supply of nerve force to the muscles because of an earlier and greater development of the brain upon one side. (Professor Gratiolet.)

4. Obstruction to the flow of blood in the vena cava, by the pulsation of the aorta. (Dr. Barclay.)

5. Inspiration produces, mechanically, a superior efficacy of the muscles of the right side. (Professor Buchanan.) This theory is based upon the observation of the anatomic peculiarities of the liver, lungs, etc., and their supposed influence upon the center of gravity of the body. (So far as pertains to the center of gravity, the theory has been adopted by Dr. Struthers and by Dr. Allis.)

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6. The center of gravity theory. The influence of the weight of the viscera of the two sides of the body, upon the position of the center of gravity. (Dr. Struthers, accepted by Buchanan, Allis, etc.)

7. The origin of the subclavian arteries, the left before the right in the lefthanded, with superiority of blood-supply to certain structures. (Professor Hyrtl.)

8. The development of one cerebral hemisphere more than the other. (Wilson.)

9. The Topsy theory—"just growed."

These theories merit little argument in rebuttal. No. 3 and No. 8 are essentially the same, and, of course, are mere avoidances of an explanation. No. 2, No. 4, No. 5, No. 6 and No. 7 are not based upon facts, and contain fallacies of observation, rendering them at least of insufficient reach and validity. No. 9 is almost as good as any or all of the rest, and we are left with the frank confession of Dr. Struthers, that the mystery "has baffled satisfactory explanation."

In a large way and notwithstanding a certain number of exceptions, it is an illuminating truth of biology that "the ontogeny repeats the

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phylogeny." We can, therefore, never explain the phases of development through which an organism passes except by knowing the corresponding stages of evolution of the line of its ancestral forms. If, therefore, we ever solve the mystery of righthandedness and lefthandedness, it will be by the study of the conditions, habits, necessities, etc., of the ancestral types when righthandedness and lefthandedness arose. The infant of a few months shows no signs of preference in the use of the hands; it is simply nondextrous, or ambisinistrous. Almost as soon as it exhibits any conscious effort toward skillful use of the hands it usually begins to show signs of righthandedness. Before it walks, before it is one year old, righthandedness is clearly pronounced. Baldwin (POP. SCI. MO., Vol. XLIV.) has demonstrated experimentally that it is plainly established as early as the seventh or eighth month. The period in phylogenous savage life to which this of the infant corresponds must, therefore, be that of the earliest phase of humanization. The animals, even the anthropoid apes, do not, so far as I have observed, exhibit it. Vierordt says that parrots grasp food with the left foot, by prefer-

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ence, and that lions strike with the left paw. Livingston is quoted as thinking "all animals are lefthanded." I suspect this is all error, because, as a rule, it would disadvantage rather than help in the animalian struggle.

Since any sort of consciousness of the facts has existed the wisdom of righthandedness has been emphatically exhibited: (1) In the word *dexterity*, which is the prized and honored quality of savage and civilized man; (2) in the secondary meaning of the word *sinister*—unlucky, ill-omened, evil; (3) in the persistent training of all lefthanded children, by parents, teachers, etc., to make them like the rest of the righthanded world. These three facts, the residue of the psychologic habits of ages, persistent in all history, crystallized and embedded in the very language itself which chronicles all mentality, help to give us the clue to the solution of the riddle.

Skillfulness, "handiness," expertness of sense and act, were the sole means whereby the savage could win his place in the world, domesticate animals, conquer in all sorts of conflicts, supply himself with food, clothing, house, etc. It was necessary that one hand should be chosen

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to do the dextrous or more skilled tasks, for the simple reason that exercise develops and perfects function, and one would learn to be more skilled and "handy" with one hand than with both. The savage required no treatise on logic nor even any conscious reasoning to teach him this primary lesson. His food and life depended upon his learning it.

But that it was an acquirement, that the law and necessity were not exceptionless, that it was due to no absolute fatalism of anatomy or physiology, is evident from the fact that so large a proportion of lefthanded children and adults exist in all races and times. The education of lefthanded children, whereby their writing center, naturally dextrocerebral, is by forced training and long habit transferred to the left cerebral hemisphere, is another demonstration that no inherent neurologic or psychological law governs the location of the cerebral center or its peripheral outworking. When the occasions arose in the humanization process, and the demand for the differentiation of cerebral mechanisms was made, the plastic brain on either side could take up the work. And pure, or untrained, lefthanded persons are

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to-day as expert as their righthanded fellows. All that is needed to explain righthandedness in 94 percent of children is some ancestral savage custom, habit, or necessity, widely prevalent, which inclined to the use of the right hand and eye for one or two exceptionally intellectual tasks. The inheritance of aptitude, the force of custom, and the necessities of the struggle for existence would certainly fix the persistence of the peculiar excellence.

We must not forget that the somewhat sudden and clear preference of righthandedness and lefthandedness of the child of to-day was in the far-away ancestral line spread out over long periods of time. A year or two of the child's life represents thousands of years of slow acquirement and habit.

Again, it should be remembered that even in our preferences and habits it is only in a few things that one hand, etc., has the greater expertness, accuracy and rapidity. It is often rather a division of functions, a differentiation of ability, than a unique one. In the righthanded the left hand does many tasks of as great or greater importance, and with equal or superior skill, as the right. In eating, the

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fork is now more used than the knife; in gunning, the left hand is given the vastly more important, difficult and onerous task; in chopping, hoeing, shoveling, picking, lathe-work, railway locomotive engineering and other tasks the left arm and hand often execute the chief and more expert tasks. Especially noteworthy is the playing of the violin, 'cello and bass viol. The "fingering" is done with the left hand, and forms a striking reversal of dextrality, because it is by all odds the function requiring more manipulative skill, accuracy and rapidity. I do not know that the fact itself has ever been observed and stated, but certainly the reason of this strange contradictory practise has hitherto escaped the attention. It is, I think, due to righteyedness. With few and easily explained exceptions righthandedness is a result, or a concomitant, of righteyedness. If the violin, 'cello and viol were fingered with the right hand the learner would be greatly handicapped by the foreshortening which would exist as his dextral eye glanced along the neck of the instrument straight in front or below this eye. The learner must see his fingers and gain precision in placing them by careful visual esti-

mates. But when placed *sinistrad* the right eye sees the neck of these instruments and the fingers at an angle which permits more accurate observation, estimates of distances, etc., than would be possible if the instrument were fingered with the right hand. In those instruments necessarily held in the median line, some wind-instruments, the flageolet, hautboy, etc., the right hand asserts its selective and more difficult task. When the hands are not seen at all, as in the flute, fife, etc., the right again has its choice. No pupil with lefthandedness established can learn piano-playing easily. I know of one who was a great lover of music who failed utterly after long perseverance.

There are other cautions to be emphasized relating to the acquirement of righthandedness by the savage: Nearly all the actions which we now call righthanded were in primeval times to him unknown. This is especially true of three things. Knives and forks have only been used in eating for a few hundred years. He ate with his fingers, and one may suspect he used the left as much as the right in this way. The Mussulman custom and its reason are, of course, both modern. Secondly, the modern

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gun and revolver had not been devised. The bow and arrow, the spear, boomerang, club, etc., could be used as well with the left hand by the lefthanded. Thirdly, writing was unknown, or relatively so, and, as we have now learned, that locates the speech center in the cerebral hemisphere opposite the writing hand. It is thus evident that righthandedness in the savage, at the time when it began to become habitual, must have been at best only partial, incomplete, and for a very few acts. The lefthanded arrow-chippers, basket-weavers, club-wielders, sewing-women, etc., even if more numerous relatively than in civilized life, would perhaps attract little or at least less attention than now, and would be less discouraged, surely less taught to reverse the natural inclination.

In default of systematic banding and military training, also, the lefthanded spearmen, bowmen, swordsmen and clubmen might not have much attention directed to themselves and sometimes might have an advantage over their single and righthanded adversaries, *e.g.*, in tilting. The preference in heraldry for dextral quarterings, etc., is by no means uniform.

But there was one overlooked factor which

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was doubtless decisive in setting up the trend toward righthandedness. This was the development of sign-language synchronously, and even preceding that of spoken language. The ineffaceable relics of this long and arduous period exist in present day language, plainly in many savage tribes and customs, but the most striking proof is displayed in our so-called Roman numerals. The fingers of the hand held up, or counted off, were beyond question the beginnings of arithmetic, the means of barter, the method of stating the fundamental fact of number requisite in all thinking and doing. Military and intertribal dealings, especially made the custom powerful and even sacred. One finger was the origin of our figure *one*, the second equaling *two*, etc., up to *five*, or V, which fork was made by the thumb stuck up opposite the first I. When the counting was more than five, the other hand was made to represent the first five, the digits being added up to ten, when two forks were used, or the crossed thumbs, which constituted X., or ten.* The impressive

* It does not matter with which hand the first numbering, in some cases, was done; the intelligent attention must have been director to the action with the dextral or spear side. Homer and the earliest Greek vases show the right was *ἐπὶ δόρυ*, the spear side, and *ἐπ' ἀσπίδα* the shield side.

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ceremonies of warring and bartering tribes would stamp with distinctive approval the hand used in the sign-language, and henceforth it would become the honored one, the stamping and writing hand, and in time the sword-hand. The right was chosen as the sign and numbering hand because the left was naturally used for the highly important task of guarding the sinistrally-placed heart with the shield. War is the substance of all early history and of the savage æons which preceded all history. Dr. Flint (*The Sun*, April 17, 1904) says that deaf-mutes may have an aphasia that prevents the use of the right hand in the sign-language.

All the progress of evolution of the higher forms of animal life has depended upon eyesight. Self-motility and intellect are conditioned upon ocular function, and civilization is possible only by perfection of ocular function. What no Darwinian has ever seen is that the survival of the fit has been for the greater and controlling part the survival of the ocularly fit, and the exclusion of the unfit has been of the ocularly unfit. The development of visual perfection has conditioned the genesis and advance of the higher biologic forms at every step. The

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fact is self-evident when one thinks of it, for all action is dominated and permitted by the sight of the external conditions in which movement must take place. There is a striking and demonstrating proof of all this in the embryology of the eye as contrasted with the general embryology of the human fetus. The formation of the eye is well under way in the second or third week, but the differentiation of the motor muscular tissues is not clear until some four months later. More significant still is the fact that the eye is a part of the brain,—the brain itself comes out to see, the retina being cerebral substance told off to a special peripheral and extracerebral function and placing. This is so with no other organ of the body, and it not only demonstrates that vision and intellect are united in a common work, but that they are united in being, one in origin, one in nature, one in function, one in history.

That which is the nearest man's soul, the most psychic, the most immaterial of the doings and creations of his mind, is language. Its organ is single not double, its center of origin and control is monolateral in one side of the brain, and not as in the case of the hands, eyes,

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etc., bilateral, or located in the two sides of the brain. If it is to act with celerity and precision in war, game, art, hunger, or love, it must be as closely contiguous and in as immediate relations to other centers of co-ordinate and interdependent function as possible. Thus an act, muscular, emotional, or volitional requiring a number of co-operating centers must, so far as possible, be near and closely connected with the organ issuing the final command. Locate the speech center in the left half-brain and the centers of the more dextral of the bodily functions also located there will act more immediately and accurately than if some of the necessary data were furnished by centers in the right half-brain. This is the fundamental condition and necessity of righthandedness. But righthandedness originates in righteyedness. Thus general dextroexpertness comes into being. Vice versa, of course, in the case of the location of the speech and writing center in the right half-brain and the resultant lefthandedness and sinistroexpertness. The four-footed vertebrate with his right eye governing dextral function and dextral dangers, furnished the biologic habit of righteyedness to general dex-

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tral function and of lefteyedness to general sinistral function, so that the prehuman organism brought to anthropology the unfinished mechanism which finally developed righthandedness (or lefthandedness) in our savage ancestors by means of war, barter and sign-language.

Righthandedness and lefthandedness has too long been considered as a riddle, a mystery for dilettante writers, at best as a matter of scientific play. But they or their co-ordinated functions are the most serious of practical concerns, the source of infinite suffering, of innumerable tragedies and even suicides. Every physician and especially every ophthalmologist, absolutely every orthopedist and neurologist must in the future concern himself vitally with the matter. The 20,000,000 patients with lateral curvature of the spine are products of morbid visual function. And they are begotten by the schools so that the pedagog may never rid himself or herself of an awful duty. In every school room of fifty pupils ten are scoliotics and at least twenty are also suffering from terrible and life-wrecking diseases caused by eyestrain.

The "ambidexterity" crank is deserving of a more severe punishment than any other of our many criminally insane.

CHAPTER I.

THE ORIGIN OF RIGHTHANDEDNESS.*

DEPRIVED for a time of the use of his right hand, Carlyle was struck both by the vast importance and the mystery of righthandedness. He forthwith pronounced the question of its origin as one "not to be settled and not worth asking except as a kind of a riddle." He was more correct in saying that righthandedness is "the very oldest human institution that exists, indispensable to all human co-operation whatsoever; no human cosmos possible to be ever begun without it." Since the entry in Carlyle's diary was made hundreds have despaired or failed in the same manner to see any possible solution of the "riddle," and all the time, to an extent which Carlyle could never have dreamed, the extension of the influence of righthandedness has penetrated more profoundly and dominantly into all the departments of practical, commercial, manufacturing, and social life. There is no medical science or practice which

* From the Boston Medical and Surgical Journal, Vol. clvii, No. 18, pp. 597-601, Oct. 31, 1907.

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Beyond question the beginnings of righthandedness, and of general rightsidedness, date historically to primitive war and barter and the tally-stick. The first differentiation of function in the use of the hands doubtless arose in telling off the left hand and arm to hold the shield which should protect the heart side of the body from the adversary's blows. This hand thus became known as the shield hand. Except in a few very modern tasks the fact has dictated that the left hand has been generally the holding hand, chosen instinctively for the more passive or holding tasks, those requiring the less delicate or expert proficiency. Custom and language have long crystallized into an acceptance of the usage and even gone so far as to call the unlucky and misfortunate and awkward by the words *left*, *sinister*, *sinistral*, *gauche*, etc. Conversely, the right hand was chosen for the positive fighting task, and called the spear hand, and some of the most prized virtues, dexterity, dextrousness, etc., were named after the cultivated abilities of the right hand. The oldest Greek vases, and Homer, even the cave-men, demonstrate the existence of the distinctions of shield hand, spear hand, and of righthanded-

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ness generally. In Xenophon's "Anabasis" the usages had become the routine of all military drill and discipline. In Smith's "Dictionary of Greek and Roman Antiquities" under the caption "Exercitus," may be found illustrations of the distinction emphasized. For instance:

"The facing to the right was always the usage, because if the evolution were performed in the face of an enemy, the shielded side could be presented toward him. . . . Similar maneuvers took place if the enemy appeared on the left, though, as this was the shielded side of the soldiers, and the danger was consequently less, it was frequently thought sufficient to keep the enemy in check by means of the cavalry and light troops. One point that a general had to be on his guard against was the tendency of an enemy, when advancing ἐπὶ φάλαγγος, to sheer off towards the right, each man pressing closer to his right-hand neighbor in order to protect his unshielded side, so that the right wing frequently got beyond the left wing of the enemy."

The Roman army *exercitus* fixed the working of righthand and lefthand orders down to the most minute details, and at West Point to-day the thousand peculiarities of military drill and custom and command are exemplifications of the consequences of shield-hand and spear-hand.

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Xenophon is still in command of every army in the world. Within the memory of living men companies of American militia often had, at the end, tail, or left of the battalion, a lefthanded soldier, placed there in order that his musket, carried in his left instead of his right hand, might not clash with the right hand and its held gun of his next, righthanded, fellow.

In the word *digit*, and in the Roman numerals, and in the five strokes or cuts of the tally-stick, we have the most abundant and abiding testimony as to the origin of righthandedness and the location of the speech center, in the left half-brain. Counting, writing and speaking are single functions united into act by the volition, the seal and ratification of willing. By all savages for all time, in bargaining, the right hand has been held aloft, and one, two, three, or four fingers shown and flung at the opposed bargainer. The gesture is always that of throwing the fingers or numbers at him. The whole hand is flung more energetically, when five is intended, *i.e.*, the letter V of the fork of the thumb and first digit. The scratches on the tally-stick tell the same story and the diagonal thumb line, denoting *five*, run across

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four digits from upper left to lower right hand corner, indicates the thumb or fifth number. And so on, to *ten* or X, the crossed or doubled thumbs and to all other numbers. A close study of the Chinese and Japanese numerals convinces that the Roman system described, ancient as it is, is but a late offshoot of far older oriental usage, in general features the same the world over, and ages before history began.

The significance of these illustrations of primitive and persisting sign-language, gesture-language and counting-language is that as they are executed by the right fingers and right hand, the motions of these fingers and this hand are instituted and innervated by "a center" or collection of brain cells in a certain spot (called Broca's convolution) placed in the left side of the brain. With one finger held up, or more, or the whole hand, with one or more cuts in the tally-stick made, there was (and as the schoolboy's lip-motion in learning to read demonstrates) the spoken word, one, two, three, etc. Speech is almost the sole and surely the chief muscular function that is single, not double, and which must be executed from a single initiating center of power and control. It is the

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fusion of all bilateralism, of all bodily and mental components and diversities into the unitized resolve which the whole body, mind and future, must obey. For the righthanded man this center of nervous origin and control is not in the right half-brain, nor in both half-brains, but only in the left. There also are the nervous or ganglionic mechanisms of memory, of writing, of the expert vision, of hearing, of leg-and-foot motion, which may be or are necessarily bound up with the righthand deeds, the laryngeal and vocal acts issuing in language, or resolve, or social determination. The two halves of the brain are remarkably independent and separated from each other, as a thousand facts of physiology, disease and injury to brain-substance show. Therefore an injury to the speech or writing centers or to the centers of motion of the righthand fingers of a righthanded person at once paralyzes or destroys, partly or wholly, the power of speech, of writing, of memory, the significance of words, etc. A similar injury to or disease of the corresponding parts of the right-brain has no effect whatever upon these functions and acts. The child is born with no discoverable differences

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of cerebral structure or substance of the two cerebral hemispheres, and none ever appears thereafter. But about the sixth month of life the babe, which will naturally become a right-handed one, begins to put forth the right hand instead of the left to grasp an object, and the cerebral matter about the left third frontal convolution, however unchanged or like that on the right side, is thenceforth increasingly and exclusively used to control the organs of speech, of writing and of memory. Just here comes into view the overlooked fact that the degree of righthandedness, of general dextroexpertness and even of vocal and mnemonic function is different in different persons, and also that it is all a question of growth and progressive development. In the grunting savage or peasant the speech center, although located in the left-brain, must be tremendously more simple than in a musician who knows by heart and sings and plays a thousand pieces of music, who speaks and writes a dozen languages, etc. The differentiation and complication of the cerebral mechanism whence spring all the acts begins in infancy with simple homogeneity, and grows in complexity with every year of added life. With

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each added year of differentiation the expertness grows, and it grows because the single cerebral mechanism has become more and more complex. Therefore with each added year the impossibility of educating the corresponding centers in the right-brain becomes greater. The ambidexterity sillies must therefore begin with infants if they are to succeed in making a dextral child of one naturally sinistral. Moreover, historically, the trend in all human beings is for them to become more and more exclusively and despotically either righthanded or lefthanded, so that with each added generation the impossibility of ambidexterity will increase. Even now the attempt to reverse the law as existing in school children is both useless, expensive of life and in reality impossible. No attempt can wholly succeed; none should, and the partial successes produce cripples and awkward, if not disease and tragedy. The most foolish, impertinent, ignorant, expensive, resultless and maiming fad is that of the ambidexterity mongers. They do not know what they want, do not know that they cannot succeed, do not know that they curse the victim of any partial success. In infancy the lefthanded

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child may be trained to be a righthanded one, but never to be an ambidextrous one. Why should a violinist bow equally well with both hands, and finger equally well with both hands? Why should he write equally expertly with each hand?

The fatuity becomes amazing with the recognition of the fact that righthandedness is necessarily bound up with righteyedness, with rightearedness, with rightfootedness. To train the child to be ambidextrous, eyes, ears and feet,—all must be trained to equal expertness in all tasks, and this is ludicrously impossible. We are usually as righteyed as we are righthanded, as any one can prove by looking at the image of the finger or a pencil held upright a foot before the eyes. Alternate opening and closing of each eye demonstrates (with some exceptions understood by oculists) that the right eye is unconsciously the one chosen to “fix” the image.

The reason for this general choice of the arm and hand, of eye, of ear, and of leg and foot for conjoined expert tasks is easily recognized. It insures a speedier and more accurate synthesis of the cerebral functions which must be

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co-ordinated into a single act and result. The independence of the two halves of the brain makes it necessary that the bodily organs most commonly acting together and most interdependent should be incited and controlled by the cerebral centers in close contiguity and in one side of the brain. There is a measurable slowness of nerve-current transmission (between 100 and 200 feet per second), and even if the connecting links ("commissural fibers") between the two brain-halves were much more intimate and numerous and short than they are, rapidity and accuracy of correlation and unification in willed act would be impaired, and the safety and decision of the entire organism imperiled, if one or two of the coacting centers were in opposite hemispheres. That in the righthanded all these centers of origination and control are in the left, and in the lefthanded in the right half-brain, is an inevitable consequence of the location of the speech center and writing center exclusively in one or the other. Writing and speaking are closely interdependent, both in origin (gesture, sign-language, counting, Roman-numeral or digit-throwing), and in all subsequent history and evolution.

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Their centers of origin and control must therefore be in close neighborhood and intimate union. Vision which preceded and accompanies all must therefore be in the same side of the brain. This, of course, holds as to hearing and, although less differentiated, to the associated leg and foot movements.

An astonishing and interesting consequence of all this almost draws itself. It becomes plain that, in the righthanded, intellectual life and progress are by means of the mechanisms of the left cerebral hemisphere. There is no intellect as we understand it except through speech, vocal and written, and the instruments of this function exist only in the left-brain of the righthanded, and in the right-brain of the lefthanded. Mentality of the dextral therefore lives preponderatingly in and through the left half-brain. The fact strongly emphasizes and capitally illustrates the great biologic law that all progress consists in differentiation of function. In the evolution of civilization each bit of cortical brain substance is being told off to a certain peculiar office. That large parts are still without particular and discoverable duties argues plainly for the great progress and dif-

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ferentiation of function in the future of humanity's advance. The areas of the more unused half-brain (the right in the righthanded, the left in the lefthanded) occupied by the speech and writing centers in the more active half, show microscopically no failure or weakness of part or mechanism. If they did heredity would long since have eliminated the lefthanded, and the right half-brain would become changed and atrophied except in those parts originating the muscular activity of the right side of the body, etc. Possibly, the recurrence itself of the two or more percent of lefthanded persons prevents the atrophic tendency in the righthanded. Lefthandedness is therefore probably not decreasing (probably increasing), and the forming organisms of the infant may become lefthanded, etc., with no want of perfection in any part. The emergency finds the inherited mechanism ready for its task.

In this light and by reason of these facts one sees that materialism is absolutely disallowed. The speech and writing mechanisms of the brain do not as such exist, even functionally, in the fetus or newborn child. They are creations, slow creations, during childhood

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and youth. At any time they are instruments and mechanisms, expertly manufactured by something not themselves, used as a piano-key and string, and as all the keys and strings, as the piano itself, by something that plays upon them just as a pianist plays upon his instrument. That the instrument can or does make itself, that the player and piano are indistinguishable and of one substance, are the most unwarranted of pseudophilosophic assumptions. Far better than either philosophy or religion, physiology thus demonstrates the existence of the life and spirit of man, apart from the material of his body and its mechanisms.

There is much obscurity and misconception as to what really is the nature and fact of righthandedness, righteyedness, etc. The crudest blunders, for instance, exist even in learned monographs as to rightfootedness. In dressing, a dextral man begins by first putting his left foot in the left trousers-leg; he places his left foot upon the spade or shovel; he jumps from the right foot; kicks with the left; the boxer and prizefighter places the left foot and arm forward; the rider vaults a horse from the "near"

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side, and with the left foot in the stirrup first; * the entered apprentice mason "steps off with the left foot first;" all soldiers, since time began, start the march by first advancing the left foot. All of these things are conclusive proofs of rightfootedness, and not of leftfootedness, as many claim. The right foot and leg are unconsciously chosen as the strongest, the most steady, best co-ordinated, most expert ones, with which the spring, the determining or force-giving factor, is made. It is of course nonsense that animals are rightfooted or leftfooted. The differentiation could only arise with sign-language and counting, and animals do not make gestures or count. No doubt that rightfootedness in man is not so far advanced as right-eyedness and righthandedness; there are more exceptions, less differentiation of function, etc., but it is essentially present, and in process of evolution.

Righteyedness is also subject to more excep-

* In the *Art of Horsemanship* Xenophon gives the most detailed instruction as to the method of mounting the horse, after which he says, "I think it good that the horseman should practice springing up from the off-side as well, on the chance that he may happen to be leading his horse with his left hand, and holding his spear in his right," etc.

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tions than righthandedness because of the peculiar liability of the right eye to be thrown out of its function as the "dominant" one, or leader, by many ocular diseases, by injuries from blows, and especially by a more disabling optical defect (astigmatism, hyperopia, etc.). The struggle of nature to preserve the dominant function of the right eye is patent in the case of nearly every patient that comes into the oculist's office. The right will preserve its acuteness even under a greater optical defect than that of its fellow; the left is the one more frequently diseased and lost, and even with lessened visual sharpness the right is often retained as the dextral one. For there is tragedy when from any cause the righteyed man in adult life is made into a lefteyed patient. Every act and co-ordination and judgment becomes slower, more awkward, more difficult and more inexact in result, because the visual factor in every act (and even every thought) is furnished by the opposite far-away and more inexpert center. There are few greater afflictions than one I now am witness of—paralysis of the upper lid of the right eye in a righteyed person occurring in full adult or late life. The most amazing conse-

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quence of righteyedness is lateral curvature of the spine. Approximately about 20,000,000 of the people of the United States have lateral curvature of the spine, and of these about three fourths, or about 15,000,000, indirectly owe their disease to righteyedness. The deforming and crippling writing position which causes the deformity of the 15,000,000, is due to the necessity of bending the body and head to the left in order that the right eye may see the pen point. The right eye must see the intellectual thing written even though the distortion of the back and tragedy of a life result!

When a righthanded person is made into a lefthanded one by a broken arm, or by the equal misfortune of a foolish parent wiser than nature, the results are almost sure to be baneful. If undertaken early enough in youth, the foolishness of trying to train the right hand by whipping, tying up the left, etc., may sometimes succeed, but at the expense of a life of trial, handicap, or even wretchedness and disease. Ill success in life is often caused by this folly. It is chiefly the writing act that arouses the sorry parent and the ambidexterity-crank to their impertinent opposition. But it is precisely

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the writing act which locates the speech-center in the side of the brain opposite the writing hand. Writing, bound up with speech and memory, is the demonstrated origin of the localization of the speech-center. Science, disease, physiology, tumors of the brain, etc., have proved that one may be lefthanded in everything except writing, and that the speech center is in the left half-brain. I have a patient who, as a boy, was cruelly compelled to stop writing with his left hand, and after years of torment he was made a dextral writer. And for forty years he has never been able to think and write at the same time. He cannot write the simplest letter that requires thought, planning, or judgment. He sends miles or waits hours for a stenographer, and can dictate the most technical engineering plans with clearness and rapidity. Another patient has been made mentally morbid, and a life of invalidism has resulted from the same cause. In the United States there are about six million originally or persisting lefthanded persons, a portion of whom are mental and even physical cripples from the injudicious antipathy of parents or teachers to the "south-pawed." In compara-

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tively few cases is the attempted change entirely successful. They have a sufficiently hard time to get lefthanded work benches, tools, etc., and to pursue the avocations of the righthanded, without doubling their handicap by dividing the centers required in a composite act between the two dissociate brain-halves. How pitiable is the lot of the lefthanded soldier! I have two thorough-going lefthanded patients who by training have learned to shoot a rifle from the right shoulder, but they depress the right eye below the gunstock and awkwardly sight with the left eye! When all his sinistral functions are performed by the lefthanded man by means of the cerebral centers located in the right-brain hemispheres he is as efficient, quick, intellectual, etc., as the righthanded person. The Jewish lefthanded slingers, it is said, could cut a hair set up as a target. Because there are a few persons with the heart on the right side of the chest it would seem to be even more the duty of the ambidexterity societies and of officious parents to remove it to the left side by surgical operation! Let the lefthanded child alone! Nature is quite as wise as the ignorant intermeddlers. For ages the stranger, the un-

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known and unusual person has been looked upon with dislike, and has even been persecuted because he differed from the one without other excellencies than that of being like his neighbors, or like the majority of them. The dislike of lefthandedness is a relic of the same vicious egotism. The lefthanded person is stupidly charged with being "sinister" and unlucky, and all because ages ago to the left or shield-hand was given the natural task of protecting the heart and life of its master!

And a little quiet and unprejudiced observation would have shown that it is rather a division of tasks, a happy and advisable differentiation—not subordination—of function, that is coming about in the jobs which the left hand is commissioned to do. In the sterling old tasks of shoveling, pitchforking, chopping with the ax, etc., the left hand almost divides the honors equally with the right. In locomotive-engineer driving, it is indeed the left hand that is on the throttle valve. Especially in the musician's art both hands must be equally expert and active. The fingering of the left hand of the violinist is technically as fine and dextrous a task as the bowing of the dextral hand. It is of

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vast significance that all tasks should be divided up and allotted to each hand, each eye and foot (perhaps to each ear?)—all except the one of intellect bound up with writing, speech, and memory, which, necessarily single, must be shocked into action by a single and not a duplicated set of organs, which are placed only in one cerebral hemisphere. It is of no advantage to be able to eat with the knife or fork with each hand alternately and equally well; it is a positive disadvantage. Should every musician have two pianos, one as now constructed and another with the bass keys on the right, and should he learn to play equally well upon each piano? That is what ambidexterity means. The poor lefthanded person is already almost entirely shut out from any musical calling, except that of singing, and there are many other avocations in which he is handicapped or doomed to failure. From this point of view one may wonder if the number of the lefthanded will really decrease in the struggle for existence in civilization's progress of the future. There are no statistics to help us decide the question. The exclusion of such unfit ones will at least be only hastened by any interference with nature's

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production of lefthandedness. With a very few years in childhood of nascent righthandedness or lefthandedness started, the habit becomes so fixed that years of punishment, derision, strapping up the left hand and other methods of torture are utterly powerless to alter the developing and educating speech center in the right-brain.

The bleatings, mooings, bellowings, roarings, etc., of vertebrate animals, together with the cries of the infant during its first months of life, are not language, or even the beginnings of language. Whether they express or are understood to express desire, pain, anger or passion, they are the voice, or suggestion of the voice, of the organism as a whole, undifferentiate, nonintellectual,—the cry of the abstract physiologic machine, wanting or pained, and as a unit; they are not inspired or guided by vision or by definite motived act. The air issues from the caverns of appetite and emotion, and in passing through the upper organs of respiration is slightly transformed into inarticulate sound. The vegetal or automatic organism is its origin and end. If innervated by the cortical centers these cries probably spring from a

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bilateral origin. Only when they become purposive in the slightest degree, when the other senses, and especially sight, are called in to furnish data and help for the motived and designed act, does the innervation of phonation arise in a single or one-sided center; the continuous evolution of the speech-center thus becomes established and progressive. The "precise" but indefinite time at which this monolaterality begins is the "precise" but indefinite time when inarticulation becomes articulation. Articulate phonation is the intermediate of specialized and designed acts; it is the voice of intellect, choice, and purpose. It is compositely formed out of the factors of sight, feeling, hearing, etc., furnished by individual, topographically placed, and neighboring cerebral centers. In a certain individual right-eyedness is doubtless the determining factor in localizing the developing speech-center in the left half-brain. The individual misfortune, possibly tragedy, comes from a compelled change of plan after the localization on one side is under way, or established. A higher error of refraction in the right eye, or the results of disease, such as keratitis, conjunctivitis, squint,

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etc., may bring about the misfortune. To produce lefteyedness, when obviabie, by reckless operations is, in the surgeon, a scientific blunder. To will and compel righthandedness in the naturally lefthanded is a crime.

Physiologically, therefore, the reason why an infant puts forth the right hand to grasp objects is because the right eye is the one which is nearest perfect visually, anatomically, or optically. The law derived from the phylum of the entire past is that the right eye and right forefoot, or right hand, must work together. In all animals the right eye governs the placing and action of the right front foot, of the right side of the body, the guarding against dangers on the right side, etc. The left eye has the same office for the left side. Heredity has place in the creation of the more nearly perfect right eye. If the left eye of the infant is the better seeing eye it will grasp at objects with the left hand, and become lefthanded. Handedness, if one may devise the word, becomes either righthandedness or lefthandedness, according to the dictating condition of the better eyedness, right or left.

CHAPTER II.

WHY IS A PARTICULAR CHILD RIGHTHANDED OR LEFTHANDED? *

IF, as I believe, the study of civilized people shows that the special incidence of righthandedness, and of lefthandedness, and of mixed types, is governed directly by ocular dominance, and only indirectly and partially by heredity, a thorough understanding of the subject will be gained by a preliminary look at the precedent animal function and habit. And this is epitomized as right-eye dominance of general dextral or right-side function, and left-eye dominance of general sinistral function. To begin with, embryology demonstrates the existence of vision long before muscles, so that historically and evolutionally vision governs motility; the very cleavage of the brain in the two so independent halves of all types was doubtless due to the unilateralism and independence of ocular function. The more primitive the type the more on one side of the head was the governing eye,

* Long Island Medical Journal, November, 1907.

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and the more independent it was of its fellow upon the other side. A motion to strike one eye from its side does not cause the other eye to wink or to protect itself or the animal from injury. One eye governed one side of the body (because vision must incite and control all action), especially the co-ordinated front foot of that side, but also the hind one of that side to a less degree or less accurately; and the other eye acted for the other lateral organs in the same way. Fewer and less accurately co-ordinated commissural fibers between the two hemispheres were then necessary than when later complication and specialization arose. It is evident that when one eye was placed upon one side of the head, not looking forward, and separated from the other by a protruding mass of organs and bony structures, it must act independently of the other, to see objects upon that side of the body, to protect it, and to govern the muscles of its side. So long as the forefeet are equally used, *i.e.*, so long as no differentiation of their function arises, there can be no question of the existence of righthandedness, or rightfootedness. The chief, most frequent, most necessary of all animalian four-footed

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function is placing first one front foot, and then the other front foot, in the safe and right place and position, especially in rapid motion, fighting, defence, etc., etc. That placing of the right forefoot must be dominated by the right eye, and of the left forefoot by the left eye. There is simply divided dominance of the eyes, each supreme in the control of its correlated lateral organs. The peculiarities of the avoidance by a horse of a stone or log in the road, by, say, the right hindfoot, the stone at the instant out of sight, and the right eye perhaps governing the avoidance of a similar impediment in front by the right forefoot, is a most instructive thing. The co-ordination of eye and front foot is more exact, and the very awkwardness of the hindfoot is significant.

The approach toward binocular fusion, the advance of the eyes toward the front of the skull, the degree of forward-lookingness, if one may so speak, is measured and indicated by the progress toward parallelism of the ocular axes. Recapitulated, this progress towards parallelism is steady from lower to higher types, reaching complete parallelism only in man.

In the most civilized of humans, the literary

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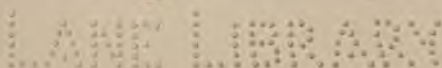
and handicraft workers, the progress does not end with parallelism, but the ocular axes must be sharply converged upon a point 12 or 15 inches from the eyes for ten or more hours a day.* And with every step of this progress in human beings there must be a like increase of complexity in the interrelations between the ocular government of common or bilateral movements and functions. The number of things to be seen by both eyes, and to be done by both hands, etc., is constantly increasing. But, *pari passu*, there is an equal differentiation and specialization of functions of the two hands. With every expertness gained, one hand is told off to that extremely specialized task, and the other perhaps to another, but at least never to the same. And still the old great rule, generally speaking, not only remains in force, but is increasingly observed: In the righthanded the dextral hand is chosen more and more for the heavier, the higher, more intellectual, more skilled, more difficult, more minute, more detailed task, and the left is still the holding,

* Lack of converging power to carry this out gives the practical oculist his pathologic problems of exophoria and divergent strabismus.

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assisting, and complementary helper. In the lefthanded the rule is reversed, but there is no inferiority in the expertness, etc., of the left hand in these cases, although a high percent of their ancestors were righthanded.

The rightsided cerebral convolutions retain all the aptitude for governing skilled functions which the left half-brain possesses in the majority. The explanation of this seeming contradiction of evolutionary law is seen in the recognition of the fact that "the ontogeny repeats the phylogeny"—for righthandedness and lefthandedness is not prenatal in origin. It begins with the infant's coincident function of eye and hand, and begins at the period of ontogenetic development corresponding to that of the phylum when forefeet began to be used as hands, and when one hand began to be preferentially or necessarily used for a special task. In human historic development it emerges into clear view with the specialization of the left as the shield-hand and holding-hand, and of the right as the spear-hand, the counting-hand, etc., and finally as the writing-hand. It is thus a late acquirement of the phylum. Thus the individual born now begins to acquire it, for



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either half-brain, at about six months of age, and the lefthanded is as quick to learn it and is just as expert with his left hand as his righthanded brother with his right hand.

Two things need to be recognized, emphasized, and always borne in mind: First, there is no inheritance of completed mechanism, or even of predisposition towards it. Either cerebral hemisphere may be the seat of the speech-center, and it may innervate the more expert hand, with absolutely no inferiority of expertness in the less commonly chosen right half-brain.* Thus heredity has, directly, nothing whatever to do with the existence of the 94 percent of righthanded, and 6 percent of lefthanded. If those who are Mendel-crazed, or who see "the iron and adamantine law of inheritance" in everything, ever tried to trace such supposed laws in the incidence of righthandedness, they quickly abandoned the hunt. Because they found that here no such "iron

*The fact is a striking example of how little pathology of the laboratory kind has to do with life, function, or the origins of diseases. It is a matter of vast significance to a man whether he is righthanded or lefthanded, or of mixed type. But millions of slides by all pathologists could not tell to which class the dead man belonged.

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law" exists (it exists nowhere, forsooth!), and that some other mysterious agency is at work, of which they could have no knowledge. "The wind bloweth where it listeth," and the least or the most investigation of actual cases shows that lefthandedness or righthandedness arises most incongruously for the iron-law-of-heredity criers, has even nothing to do with heredity directly. For several generations, *e.g.*, neither paternal nor maternal ancestors of two children were lefthanded, and suddenly those two children are found to be lefthanded!

Secondly, just as there is no endowment of righthandedness or lefthandedness, as a completed mechanism, nor even of any sign of an inherited exceptional aptitude, so there is no completedness of the acquirement. Every baby of a year of age shows some beginnings of the peculiar expertness, but the progress in specialization and in the acquirement of kinds and degrees of expertness never ceases while life lasts. And there are as many mixes of peculiarities as there are individuals; there are almost as many anomalous as there are typical cases. As a rule, of course, the hand chosen for the most expert tasks is increasingly chosen,

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and people tend to fall into two great classes, the righthanded and the lefthanded. All lefthanded mechanics (and now everybody uses machines!) are handicapped and bothered by the fact that all machines, even to screws, are made for the righthanded. Not to be forgotten also is the number, large in the aggregate, of the righthanded who, by accident, injury, etc., lose the superior expertness of the right eye, right hand, right leg or right foot; and, conversely, the number of the lefthanded who suffer similarly as regards their sinistral expertness. In such cases there is a transfer of task to the opposite organs, and a slow, difficult, and always imperfect expertness is acquired. But in every case there is a crippling, and a lessening of productive capacity, a disadvantaging in the struggle. And more surely is there a mixing from the ground up, or rather from the top of the head down, of hitherto co-ordinated and related functions. The center for the intermediation of an absolutely necessary psychic and neurologic datum of the engineered composite act has to be transferred to the opposite side of the brain. There is, of course, halting, indecision, slowness, or genuine inhibition of

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function because of the difficulty of correlating the data from the two sides of the brain. Many a case of stuttering, probably most, slowness and morbidities of speech, etc., are due to this division or misplacement of the innervating centers in opposed cerebral hemispheres—all bound with righteyedness, righthandedness, or the opposites, etc.

Think also of the appalling amount of misery, mental and physical, the disease, the shame, that for untold ages has been thrust upon the lefthanded by parents, social custom, etc. There is even now scarcely a poor lefthanded child who is not cursed by the attempt to make him righthanded. There are about six million naturally lefthanded in the United States! Every one of them, if not absolutely diseased, is made morbid, less happy, handicapped, by the peculiarity a little, by the cruelty of changing it a vast deal. Add the millions of millions that must have lived since the first finger of the dextral hand was held up in counting! In savage times the savage mother and father, and tribe, must have horribly maltreated the poor unfortunates. There is only a little proof of this in the *Keep to the Right* of our common

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law, in the wrong and ignominy associated with the words *sinister*, *gauche*, etc., and the honor born of mere contrast, of course, in *right*, *dextrous*, *dexterity*, etc.

Focus the converging lines of the argument! The 94 percent by all laws of inheritance and of mechanics should long ago have extinguished the relatively few lefthanded anomalies. They persist, and perhaps increasingly. The mixed types are certainly increasing. The vindictive effect of persecution, shame, and cruelty, united to the number of the mutilated, would add powerfully to exclude them in the long history of human evolution. They reappear as numerous, as mysteriously, apparently as illogically as ever, and certainly in mockery of any known law of heredity. Why?

To understand the answer it should be remembered that forward movement of a four-footed animal, composed of two poorly united or co-ordinated longitudinal halves, must be by means of the governors of all movement—vision. One organ of this vision was for the one badly co-ordinated half-body, the other for the opposite half. The brain was halved, also, but a slow and poor correlating mechanism was

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begun and is being improved, at present much improved. Even now the right eye is united in function with the right hand, the right foot, etc., and especially with language, the crowning achievement of humanization. The centers of righteyedness, righthandedness, rightfootedness, speech, and writing (with memory and intellect) must be topographically in the left cerebral hemisphere to insure speed, accuracy, and co-ordination of united sensation, thought, will, and action. In the lefthanded, of course, the same law holds of the right side of the brain. In one or in the other, therefore, a little by inheritance, and more by necessity—but not divided or mixed! That is disease—and the god of evolution is a physiologist, not a pathologist! (He seems to have made some pathologists, but not intentionally; and they are pathological!)

The right cerebral mechanism, although disused for speech-function and righthand function for 94 percent of all ancestors, and for a special family group, for untold generations, still retains an equal aptitude and mechanism for function with the left. The peripheral mechanism of left hand, left foot, etc., also

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retain their coequal educability and proficiency. What varies, and what is the special variant cause beyond the complete control of the biologic mechanic, which induces the individual incidence of righthandedness and of lefthandedness?

It is the eyeball. I have measured 20,000 or 30,000, and no one was perfect in shape. It is a poor and makeshift mechanism even apart from its morphology; but, so difficult, so impossible, is the task of making it mathematically perfect in shape, *i.e.*, to one-three-hundredth of an inch of ametropia (and that may be pathologic in resultant function) that such perfection of dimensions has been impossible. An approach to that perfection has been attained in the ages, and by means of that most powerful of all the agents, the exclusion of the unfit, the exclusion of the ocularly unfit.

When the child begins to reach out for and to seize upon objects with its hands, the question arises at once—with which hand? One is usually all that is necessary, and one must be selected. Then begins either the life-long and increasing preference, selection, and selectability of the right, or of the left—or the history

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and perfecting of righthandedness, or of lefthandedness. The significant thing is the order in which the peripheral functions appear and develop in the child. First of all, long preceding, causing, and governing all others, especially of motion, is Vision. The lesson of embryology is illustrated in the baby's life. When the muscles of the arm and hand are ready for any movement, vision has been long ready to direct it and make it purposive. Then the correlated center for speech-phonation is located in the brain-half opposite that of the dextral eye in the righteyed, and vice versa in the lefteyed. The foot-and-leg correlation is latest and always more imperfect and variant.

Many tests may be made of the now well-known fact I have so long urged of the dominance of one eye in vision; of the existence, under certain circumstances, of two images of one object (not strabismic, but normal and necessary); and of the psychic ignoring of the image of the nondominant eye. A sheet of paper vertically held before the eye, with the edge against the nose, followed by alternate closure and opening of each eye, illustrates; or the pencil or finger may be held in almost

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any position and the gaze fixed beyond it. Other devices prove that certainty of manual seizure, accuracy of mental representations of spacial, topographic, and stereoscopic relations (with precision, safety, etc., of co-ordinated actions) depend upon the frequent preference of the image of one eye, and the ignoring of that of the other. The right eye and right hand must work together, the right eye usually governing the actions of the right hand; and the same of the sinistral organs.

If now the right eye is more defective, more ametropic, if its vision is poorer, more difficult, or more painful than that of the left, the left eye must be chosen to govern hand-action, and so, of course, the left hand will become habitually the more chosen, the more expert, and the more educated, for the special task, and soon the child is seen to be lefthanded! Fight it all, tie the left hand behind the back, beat it, shame the child? Not so; the cause, the faulty right eye, will remain uncorrected and unthought of by all such absurdities and cruelties.

In the 94 percent and at the beginning of the function of *handedness*, the right eye is the better eye. Even in adults oculists have found

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out that, as a large rule, the right eye is more nearly perfect than the left, is less subject to disease, accident, etc., and that the "unconscious" wisdom of the organism will protect and cure it more certainly than the left (except, of course, in the case of the lefteyed). And when righteyedness is once established, Nature will preserve it in despite of later oncoming amblyopia, ametropia, or disease, which then handicap it much more than the left. The role of heredity is that of passing down the more nearly perfectly formed eyes and the more nearly perfect right eyeball. The directly acting exceptional cause is the more imperfectly functioning right one at the time handedness is to become either the right or the left variety. I could adduce a hundred clinical proofs of this. And it is not to be forgotten that the babe's eyeballs are smaller, and hence more ametropic than larger eyeballs, surely more hyperopic morphologically—a fact of most suggestive importance.

A hundred questions and considerations arise: Handicap the infant's left eye in beginning lefthandedness? The problems of equidominance, and of divided dominance? The

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civilization, the reaction of the righthanded organism to the environment (in the language of evolution), explains all the puzzles of the rule of the road.

Primitive war, as Homer, chivalry, and present-day savage customs demonstrate, regardless of the number of combatants, was a matter of individual encounter, of hand-to-hand conflict. Even when archery, and throwing of spears, javelins, etc., came into use the essential individualism was not changed, and the shielding of the left side, and aggressive use of the right hand continued. All military tactics and drill of numbers was then established as righthanded, down to the most minute particular—and so continues, indeed, although the flung weapon weighs a thousand pounds instead of one or two pounds, and is thrown five miles instead of twenty or fifty feet. After the Trojan war, chariots fell more and more into disuse, and cavalry began to take their place, but this in no way changed the evolution of righthanded tactics. In Alexander's time the right flank of the phalanx was the post of honor, called the head, the left the tail, and marches and movements were made by the right. The commander

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had his station on the right. So strongly established was righthandedness as early as the half-legendary amazonian times, that the Amazon had her right breast excised in order that she might hurl the javelin and shoot the arrow with greater freedom and accuracy.

Thus not only righthandedness in the vast majority of people, but with it righteyedness, etc., firmly fixed and differentiated, comes down to the beginnings of civilization. But this is far from implying that in meeting, either two or thousands of people invariably passed each other to the right. This is proved by the classical instance given by Dante in the eighteenth Canto of the *Inferno* in these words—translation of Longfellow :

Even as the Romans, for the mighty host,
The year of Jubilee, upon the bridge,
Have chosen a mode to pass the people over ;
For all upon one side upon the Castle
Their faces have, and go unto St. Peter's ;
On the other side they go unto the mountain.

Not only was the Papal order necessary to make the crowd keep to the right in coming and going, but a barrier was erected along the

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middle of the bridge so that the crowd could not interfere with each other. Further particulars are given in Longfellow's note to the passage, and by other commentators of Dante. In our own times the custom of foot-passengers is more firmly established, "as was well illustrated recently in the Paris Exhibition in the case of the two large wooden bridges erected opposite the Trocadero to convey foot-passengers over the roadway. Here, although for what reason was not apparent, the authorities commanded the people to pass over the bridges to the left, instead, as in the case of other bridges in the same exhibition to the right. After crossing the bridges the majority of the crowd would be seen bearing to the right, causing endless pushing in crowded days." But that many, especially women and children, are to-day reckless of the rule, is illustrated in the crowded side-walks of American cities.

Whenever, and that was generally, the custom and rule of orderly government was established by military usage, the ancient and persistent habit of passing to the right arose naturally from the necessity of keeping the enemy on the left side. This was the shielded side

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and gave combatants greater safety, as well as insured greater freedom and efficiency for the aggressive right arm and hand.

The crux of the difficulty in explaining divergent usage is encountered by the strange seeming anomaly of English practice. Wherever English usage obtains, the carriages and horsemen pass to the left, although foot-passengers pass to the right. That the foot-passengers keep to the right is natural, because it was derived from ages of military precedent. But another and overlooked fact doubtless contributed to prevent the English walkers from adopting the wagoner's rule of passing to the left. This was the growth of town and of city-life. All urban life was conditioned by narrow streets, so narrow that our modern city alleys are in comparison wide.* At first, indeed, there

* St. Evremond makes his visitor say that in the Paris of his time the streets were muddy whether it rained or not, because everybody threw rubbish of all kinds into the middle of the streets. Ladies had to be carried across the central gutter on the backs of their servants. Men wore top-boots, like those of postilions. Blocks of vehicles constantly occurred, and then there was no respect of persons; ladies whose carriages happened to be entangled in them had to listen to the most frightful oaths and language. There were often duels with whips. Victory did not remain always with the most

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were no sidewalks, and there was room at the sides, when a cart or carriage occupied the center, for only one person to walk between the wagon and the houses. Hence plazas, open spaces and squares, were the meeting places of the citizens. Quarrels and fighting were always taking place in the "streets," garbage and refuse (*gare à l'eau!*) was thrown from the windows into the center of the streets—which thus became open sewers, and the mud, etc., of passing vehicles had to be avoided with great dexterity by the foot-passers. And literally with great "dexterity." The left or shielded side, although shields might not be used, would naturally be that presented to the center of the street. The right side was thus chosen to keep the right hand or armed side of the body free for action, to avoid the mud, to escape the refuse flung from above, etc. And if one pro-

ful-mouthed. The most dilapidated fiacre would have remained where it was until nightfall sooner than have made way for a court-carriage. Blind people and blind mendicants, criminals and pickpockets thronged everywhere. To the clashing of bells were added the shouts and cries of the perambulating dealers in vegetables, milk, fruit, rags, sand, brooms, fish, and water. The water-carriers numbered some 20,000, each of whom distributed from 30 to 40 pails a day. The tumult of cries kept up night as well as day.

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tected a lady, she was as to-day, given the side next the house-walls. When wider streets and sidewalks came into existence the right-passing custom was already established; and the still-remaining narrow ones in old cities insured its maintenance.

But why did the English early adopt the habit of passing their vehicles to the left? The contradictory rules have tormented visitors, evolutionists, the correspondents of *Notes and Queries*, and many periodicals of the last one hundred years, and have been epitomized in many forms, the most common being this :

The rule of the road is a paradox quite
In riding or driving along;
If you keep to the left you are sure to be right;
If you keep to the right you'll be wrong.
But in walking, a different custom applies,
And just the reverse is the rule;
If you keep to the right, you'll be right, safe and wise;
If you keep to the left, you're a fool.

The English rule of the road as to vehicles obtains on the continent only in some Swiss Cantons next to Italy, and in Italy. Nowhere, apparently do foot-passengers, in meeting, ever pass to the left. The method of passing when

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overtaking another wagon or carriage is also a result of that adopted in meeting. If wagons pass to the right they overtake to the left, and *vice versa*. The rule of all nations at sea, including the English, is uniform—Port your helm!—*i.e.*, pass to the right! This international rule was settled in 1862, yet Harper's "Book of Facts" says that near Great Britain alone there were in the six years ending 1895, some 13,000 collisions at sea.

The English rule of the road was of course socially recognized long in advance of any formal laws or decisions on the subject. So far as I can learn, the first Act of Parliament was enacted in 1835, and reads as follows:

Any person driving any carriage whatsoever, or riding any horse or other animal, who meeting any other carriage or horse or other animal, shall not keep his carriage or horse or other animal on the left or near side of the road or street, or, if passing any other carriage or horse or other animal going in the same direction shall not in all cases where it is practicable go and pass to the right or off side of such other carriage or horse or other animal, shall be liable to a fine not exceeding 10 shillings.

Any person riding any horse, and leading any other horse, who shall not keep such led horse on the side farthest away from any carriage or person passing him on any public road or in any street of a town shall be liable to a fine not exceeding 10 shillings. (In 14 and 15 Vict. Cap. 92, Sec. XIII.)

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The led horse, and especially if the man is himself mounted, requires the man's right hand in leading on the halter of the led horse. Another evident reason why the led horse should be at the right edge of the road is to avoid dangers, both to the led horse and to the approaching person, if the led horse were to pass in the center of the road, and thus graze the passing vehicle, man, or animals.

The universal ancient custom, derived from military drill and righthanded habit, of passing to the right, was therefore unexceptionally continued by all nations except two—England and Italy—and in these two it was continued as to sea-going vessels, as to led horses, and as to foot-passengers. But by these two nations the strange exception is found that vehicles pass to the left. Why?

The suggestion has been made that in England and Italy the diligences, and post-coaches, had to be protected from highwaymen and brigands and this was done by armed postillions; these sat of course on the near or left-hand horses, because they were righthanded men (and thus mounted from the left side of the horse), and also because in driving the left

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hand held the rein while the right hand was kept free to handle the firearms. The theory is that they passed to the left in order the better to fight the highwaymen who were thus kept on the right side. This explanation is scarcely explanatory. Were highwaymen not as common in other countries as in Italy and England? Could they not and would they not as footmen attack from the left side of the road as well as from the right? Usage so widespread must have a far more generally-acting and ancient habit behind it than this of robbery. All such habits as the rule of the road must have sprung from many and more primitive and humble origins, from the necessities or customs of the common people, in fact, whence as here the few later diligences and post-coaches derived their habits. The conscious legal enactment is merely the late acceptance of centuries of unconscious custom. If suddenly springing into existence a general change must be the response to a new circumstance of powerful and general application.

Contributing customs or necessities may have co-operated to effect the change in Italy and England from the natural passage of vehicles

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to the right, making them pass to the left, while foot-passengers, vessels, etc., continued to pass to the right. But it has been overlooked that before vehicles had come into use horseback-riding must have set the fashion in passing because the riding of horses, asses, mules, etc., must have long preceded the existence of the wheeled vehicle of any kind. For perhaps a thousand years (as now in a large part of the earth's surface) it must have been impossible for transportation of goods or men to be effected by wagons, and only by horses, pack-mules, etc. During this time the rule of the road must have been fixed pretty rigidly, especially as the narrow "trail" or path would not everywhere allow meeting riders to pass, but only in certain wider or more open spaces. In all civilized countries, except the two mentioned, the fact that subsequent customs demand the passage to the right shows that during the preceding centuries, the ridden horses and pack-animals must have passed to the right. One can scarcely doubt that the ridden horses of England and Italy did the same. This seems only to deepen the mystery of their contrary practice to-day.

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The mystery I suspect is resolved by the forgotten fact of the tremendous, fashion-setting, and centuries-long influence of chivalry with its tourneys, joustings, and knightly battles on horseback, with ax, sword, spear, tilting lance, or pole. Those who have studied and realize the vast domination of chivalry can easily comprehend the role it played as its vogue after centuries melted into plebeian tilling the soil, commercialism, and roads covered with wagons, coaches, etc. The horseback fights and mock-battles of the troubadours, minnesingers, knights, and aristocrats of these centuries were possible only by the contestants meeting and passing to the left. It is needless to illustrate the fact from histories of chivalry, from medieval legends, tales, adventures, etc., whether of the Arthurian cycle, or Ariosto, or a hundred aftercomers. The club, spear, sword or pole must be held in the right hand and the reins in the left; the horses and riders passed necessarily to the left. There could have been no game or reality of battle if the passing were to the right. The holding the spear, lance, ax or pole was dictated by righthandedness, and to fight each other they had to pass to the left.

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Thus righthandedness begot left-passing, owing to the peculiar conditions of the battling or jousting.

The conclusion draws itself: this must have settled the fashion of horses (and riders) passing to the left wherever chivalry was merged into wagoning by an evolutionary process. I judge it was thus transformed in Italy and England, and that on the continent the wagon and post-chaise were not slowly derived from the fashion of chivalry. We have a capital proof of the fact, as regards England, where antiquarian research demonstrates that the postilion phase of development was not long-continued or generally practised. For the postilion period (dominative and even tyrannical in France, as her literature shows) must evolutionally be considered as the intermediate between horseback-riding, and driving from the wagon-seat or box. In England the driver, as it were, jumped directly upon the wagon-seat from the ground, or from the back of the horse without a vehicle, while on the continent, for hundreds of years, the horse of the rider hauled a vehicle behind him, and the representative of the former knight and rider became a postilion.

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Lack of information compels me to confess that the actual and detailed steps of the evolution in Italy are not clear to me. But in England the postilion's office was short or non-existent, and in early times the drivers of wagons, carts, etc., walked, of course, on the left or near side of the horse or team. Probably the walking was because a single horse, instead of two or four, was the rule, as the costermonger's cart and the Irish car to-day illustrate. On the continent the teams were of two, or four, or more horses, and the postilion rode one of the "near" horses; this may be seen in pictures of Paul Lacroix, *The Eighteenth Century*, especially that of the "Carabas," on page 448. By the seventeenth century, as is shown on pages 6, 44, etc., the driver had mounted on the box, but the postilion was continued on the wheel-horse or, in case of three or four pairs of horses, on the near leader of the team. There can be no doubt that those who have explained the rule of the road for vehicles, as due to the position of the driver or postilion on the box or seat, took *post hoc* for *propter hoc*; the custom had already been long established before either variant arose. The extreme of the *post hoc*

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argument is seen in the frequently adduced statement that to have the whip-hand free, the driver sits on the right side of the seat, and *hence* passes to the left in order that he may better see that the wheels of the two vehicles do not collide. A similar illusory explanation credits the English left-passing to the fact that the early drivers *walked* on the left of the horses, and consequently they passed to the left to avoid being ground between the two sets of wheels. King Arthur and Tristram and their fellows had settled that, one judges, a thousand years previously.

Why did the American colonists from England reverse the rule of the mother country as to vehicles passing to the left? That is the remaining riddle which has perplexed every writer upon the subject. There seems to be no exception, the Virginia colonists, who were so largely horseback riders, developed the rule of passing to the right as spontaneously as the New Englanders. In Canada there appears to have been a noteworthy indecision in earlier days; in some places, as Toronto and St. John, New Brunswick, the English custom prevailed. My reports are that to-day the American cus-

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tom, if we may so name it (passing to the right) is being increasingly adopted.

The change of the colonists to the American practice has been credited to the necessity of keeping to the right in snow drifted roadways—surely an invalid argument from evident reasons. The use of ox-teams is also said to have brought the change about. This was perhaps a minor contributory cause, but, like the preceding, will not explain the spontaneity and universality of the American habit. Another explanation that has been offered for our passing to the right is that in early days of narrow and depressed roads the driver could the better judge of the danger from the bank or “lift” of the roadway on the right. Lastly, it has been suggested that lurking savages in the woods at the sides (both sides) of the road made the change of practice. But just how either cause compelled the colonial wagoners to pass to the right, or how they bettered their condition by doing so, one vainly tries to discover.

The real explanation of the change comes to light in a more careful observation and history of the actual facts and conditions of the colonial immigrants. In the first place, they were not

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in the beginning even preponderatingly English. We appear prone to forget that the first Puritan settlers were mostly Dutch, to which France quickly added her complement, both of continental or right-passing people. Then it must be remembered that the long first period of settlement was not only wagonless, but even horseless, and even English folk when afoot had never ceased to be right-passers. The ox-team, the ridden horse, and the led horse, were the first means of transportation, and all these methods would insure the beginnings of the customs of right-passing and soon establish it as the rule. It must have been a long and fashion-fixing period before the wheeled vehicle could have come into any general use to meddle with the already established custom of right-passing. Most powerful too must have been the dominating factor of the long interregnum, disuse of the English custom, whereby men's minds were freed from the influence of the special force which had made the old English custom differ from that of the continent. In the old countries war and jealousy, quarrels and crime made men watchful of each other, kept old customs in vigor, etc., while with our

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political feeling to think that "what was English was bad," and from the first this made some of the double-track railways righthand passers. I very much doubt this; the right-passing of our common wagons even in revolutionary times had become the invariable rule, and so, despite the influence of England, her engineers, etc., the righthand rule in our own railway orders was in the last century usually adopted. We still have three double-track railways which, owing to English habit, having started as left-passers, still continue the practise—the Lake Shore, the Chicago and Northwestern, and the Great Northern. All others have been righthand roads from the beginning of double-tracking. It is most astonishing to find that any railway in double-tracking should have adopted left-passing, because the engineer sits (or stands) always on the right side of his engine or cab, and uses his left hand on the throttle, observing the signals at his right. In lefthand roads it is plain that he is at a disadvantage in seeing the signals because of intervening trains or cars upon the track at his right. A great element of danger is thus introduced. This may possibly help to account

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for the existence of two exceptions to the rule in England—one between Charing Cross and Cannon Street in London, and another, one of the first suburban lines run out of London, that formerly known as the Greenwich Railway, from London Bridge to Greenwich. Various explanations have been suggested to explain these exceptions to the rule.

The danger in lefthand roads of obscured signals by intervening trains must at least complicate and make more expensive the working, and it will never be learned how many accidents and wrecks may have been caused by the unnatural method. Even on righthand roads the signal systems alone are now costing more than the entire construction a little while ago. Some 50 miles of modern signal systems are being put in by the New York Central Railway at a cost of \$60,000 a mile, or \$3,000,000 in all. There are all-controlling reasons why, once established, a modern lefthand railway can not change to a righthand one, although the disadvantages of lefthand roads grow amazingly every year. The switches into factories, mills, yards, etc., once established must be kept up, and hundreds of millions of dollars' worth of

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property and vested rights are concerned. A train should enter a switch "head-on," and established switches are so designed.

Incidentally the history of signals is of interest. At first watchmen or policemen were stationed along the line as signalmen using white and red flags in the day time, and at night lanterns of the same colors. The signalmen at first stood upon the track, then to one side. The mechanical signals are at present often overhead. When the man was displaced by a mechanical device it was at first the figure of a man, with body, head, etc., and with two arms rising and falling as did the living man's arms. Then, the signal was vertically cut in two leaving the man's half-body, half-head and one arm. That one arm is now in lineal descent represented by the dropping and rising arm of the semaphore signal. A writer in *Pall Mall*, 1902, thus describes the extension of the signal system:

However as traffic increased, fixed signals, first of the disc and then of the now universal semaphore pattern, were introduced, and worked by hand—that is, by means of a handle at the foot of the post. The idea of manipulating a cluster of these signals, together with track switches, was

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suggested by the inventive genius of a lazy Irish porter. The latter had two signals, some distance apart, to attend to; and in order to save himself the walk, he counterweighted the handle of one, and tied to it a length of clothes-line. Thus while standing at the one he was able to operate the other. An inspector chanced to see the rude though efficient mechanical device, and ordered some experiments on the same principle to be carried out in Camden goods yard—for the incident occurred on the North Western Line—with the result that the system of actuating signals from cabins or boxes by means of levers and wires was introduced. The first arrangement of concentrated levers equipped with an interlocking apparatus was invented in 1843.

The entire question of working a double-track road and its signals, and especially of a left-hand road, depends upon general righthandedness, etc., particularly upon righteyedness, and more than all else upon the fact that the driver or locomotive-engineer sits or stands upon the righthand side of his boiler or cab. The factor that has been utterly overlooked, by writers, by railway managers, by everybody connected with or interested in the problem, is that the engineer stands or sits where he does simply and solely because he is a righteyed man. It is all as easily demonstrated as the existence of righteyedness by the experiment with a pencil: Hold

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up a card or blotting sheet so that the left eye is covered by it and the right views the scene or landscape; then suddenly move the card so that the right eye is covered by it and the left eye is the used one. At once the whole scene "jumps," intermediate objects are in an entirely different relation to those more distant, there is doubt and uncertainty of localization, there is discomfort, and a clear desire and attempt to get the right eye into use. Look at moving objects and the troubles are increased; ride in the engineer's cab and they are doubled again; when sitting on the left side and looking out of the left-side window, it is necessary to put the whole head, that is, the right eye, out, in order to be sure about the approaching objects, signals and their relations. * Sit on the right side and at once it is recognized that it is only the right eye that need be put outside the window in order to see correctly and to satisfy the mind. It is most curious and of absorbing interest to see how this fact was slowly, unconsciously, blindly recognized, but without ever being uttered or brought to consciousness in the history of locomotive engine building and early railroading. If you ask any railway

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official or chief engineer of a modern railway why the engineer sits on the righthand side of his cab, disusing his skilled and strong right hand and using the left on the lever of the throttle valve, that lever on which all force and safety depends, and you will be answered by a blank stare of wonder at such a question, or there will be something said about the wagon-driver sitting on the right of the seat, about the use of the strong right hand ready for the application of brakes, for whistling, for the reversing lever, for bell-ringing, etc. All of which is most wide of the mark.

In the beginning of engine building, there was no "cab" and even in England to-day there is none; and also no seat for the engineer to sit upon. He simply looks out in the face of the wind and storm along the righthand side of his boiler, at the track in front of him. The very earliest machines, *The Newton*, 1680, *The Cugnot*, 1769, *The Murdoch*, 1784, *The Symington*, 1786, were directed by the engineer or driver in front of the boiler, and by both hands. But as early as 1790, with *The Read*, the engineer had learned that he must stand behind his boiler, although the older method of operating from

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the front of the boiler reappeared as late as 1803, *The Trevicks*, in 1821, *The Griffith*, and even in 1824, *The James*, etc. In some cases, as in *The Killingworth*, 1825, the location of the engineer was doubtful. It is interesting and instructive to watch the struggle from 1790 onward between the conflicting unconscious tendencies and demands of the righthanded and righteyed engineers (an occasional lefteyed engineer may have obscured and lengthened the progress) and the engine-makers who were still more oblivious of righteyedness. In *The Read*, of 1790, both hands were used on the throttle and there is no intimation as to righteyedness or the side of the engine whence the outlook was made. In 1801 in the *First Trevicks* engine, and in 1803 the *Second Trevicks*, the throttle lever was held in the right hand, and the engineer looked along the left side of the boiler. In the 1808 *Trevicks* this was also so, if, as appears from the picture, the right eye looking past the right side of the boiler was the custom. The dominant influence of the rule. In the 1805 *Trevicks* both hands seem to have been used, and the right hand is steadily shown in *The Blankincop*, 1812, *Stevens' America*, 1829,

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Puffing Billy, 1813, *Blucher*, 1814, *Locomotive*, 1825, *Seguin*, 1827, *Royal George*, 1827, *Stephenson's Twin Sisters*, 1827, *Hackworth's Globe*, 1830, *Bury*, 1830. In all these, probably or surely, the driver stood upon the left side of the boiler and watched the track in front from his side. He naturally wanted to use the right hand as the throttle-hand, and had not yet discovered the ocular problem. From 1829, with *The Rocket*, *The Costello*, 1831, *The Lafayette*, 1837, *The Hector*, 1839, *Hinkley's Lion*, *Gooch's Great Western* and all subsequent machines, the necessity of looking with the right eye along the righthand side of the boiler at the track and signals, became dominant, and dictated the placing and direction of the throttle-valve handle. With the late construction of the "cab" of the driver, the needs of the right eye were accentuated because the engineer in looking out of the window at his right hand is compelled to put no more than his right eye out of the cab-window. If he put the left eye out of the left-side window he would have to put the entire head out in order to see with the right eye. Thus righteyedness has unconsciously compelled the driver to disuse the right hand

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for the naturally expert work with the throttle-valve, in order that the greater danger may be avoided that would follow both to engineer and to his train, from putting the whole head out of the left window of the cab.

Among the many ocular problems of railway employees those relating to deficient color-perception are of great importance, but equally great are those regarding presbyopia or the failure of visual acuteness after 40 or 45 years of age, and especially should the diagnosis of righteyedness or lefteyedness be held of prime necessity. The left hand may be allowed, somewhat against nature, to manage the throttle-lever, but the right eye must be the absolute judge of signals, etc. Undoubtedly there are a few hundred, at least, of lefteyed engineers, signal men, etc., on our roads, and their disability for their peculiar calling is greatly endangering lives and property. Nor should it be forgotten that there are generally proportionally more lefteyed than lefthanded men. As trolley-car "gripmen" or engineers, chauffeurs of automobiles, etc., the lefteyed are at only a slight disadvantage because nothing is in front of their eyes to impede the dominant function

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of the right eye. Despite this fact the automobile chauffeur sits on the righthand seat, not only because of inherited custom, but again that his right eye may have the slight advantage of position and that his right hand may be free to use in almost every instant's emergency. In our trolley cars and electric locomotives the all-important brake is operated with the right hand.

To epitomize, the resolution of the mysteries as to the origin of righthandedness and the rule of the road may be made only by grasping the phenomena as a whole, *i.e.*, by massing the facts of the entire history from prehistoric savage battle and barter to the expert locomotive-engineer of to-day running a "limited" train at the rate of a mile or more a minute on a two-track or four-track railway. Even the cave men show that righthandedness was the rule in their time, and spear-hand, shield-hand, gesture-language, digital-counting, and the tally-stick, the world over, fixed the speech and writing and righthand brain-centers in the left half-brain—and, of course, those of the left hand and fingers in the right half-brain. War made up the life and set all the fashions of

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beginning civilization, and war together with narrow streets established the custom of righthand passing, for walkers, riders of horses, asses, mules, etc., and for drivers of all vehicles, and for vessels. For walkers and vessels no people ever changed the custom, but especially the English, while preserving righthand passing in foot-passengers and on the sea, anomalously developed lefthand passing for vehicles, and the same, of course for double-track railroads. What everybody has failed to see is that righthandedness is necessarily bound up with rightfootedness and righteyedness, because all closely united functions of the body must be correlated and their centers of motion located in contiguity and upon one side of the brain, in order to make effectual and rapid all responses of the organism to circumstance or environment. This works toward a necessary and desirable differentiation of function that makes the aims of the "ambidexterity" sillies more than resultless and foolish. Because whenever a center or congress of centers is developed in one half-brain, disuse and transfer to the other half is, according to age, either impossible, faulty, handicapping, or disease-

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producing. Co-ordinated functions of the body require co-ordinated and contiguous nerve-centers upon the same side of the brain, at least so far as is possible. If one or two dextral factors are in opposite cerebral hemispheres, responsive and quickly-acting co-ordinated functions will be slower and more inaccurate than if on a single side. The English lefthand passing of vehicles is probably due to the influence of the single-hand fights on foot, tourneyings and joustings of horseback-riders, in which meeting and passing to the left was inevitable. The custom grew and continued directly into that of the wagon-drivers. In the United States there was a reversion to the righthand passing of vehicles, because of the abeyance of lefthand passing of vehicles, and of vehicles themselves, for so long, with growth of the natural righthand passing by walkers, horseback-riders, ox-teams, and wagons with drivers on the near-wheel horse, such as is found in the later prairie-schooner, and six-mule army-wagon. Three double-track railways in the United States still pass their trains to the left, an absurd and bad custom, expensive and productive of wrecks. But despite this the engineer sits upon

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the right of his cab, because he can in this place better observe the track and signals in front and to his right, and with the dominant right eye only outside of the cab-window, whereas, if sitting on the left, he would be compelled to put the entire head out in order to see with the right eye, and, even then, because of the boiler, not so well. Only righteyedness will explain the long, doubtful, and varying custom in engine-building as to the position of the engineer in the beginning of history of railway construction and signaling.

CHAPTER IV.

STUDY OF A CASE OF TWO-HANDED SYNCHRONOUS WRITING.*

SUPPOSING the tale to have been true, Newton, I believe, would never have discovered the law of gravitation if the individual apple had fallen on his shoulder instead of on his nose, or if it had not been peculiarly colored, if it had not been blown by an odd gust of wind, or if the philosopher had not turned his ankle that morning, etc. Something individual is needed to bring truth to recognition, and the greater the number of the idiosyncratic elements the more speedily and accurately, probably, will the abstract principle or general law come to light. Generalizing over a lot of malobserved and colorless facts gets us "no forrarder." Being and nonbeing are indeed one, but what kind of a "one," and how useless is such "being," and such "nonbeing"? One swallow may make a summer if a good ornithologist is the observer of the migrating bird. In medicine all wise

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physicians know there is no "typical case," and that one instance of any common disease studied thoroughly to the bottom, in all its relations and details, is worth more than a hundred glanced at, worth more than all the glittering generalities of the text-books, worth more to the doctor as well as to the patient. The same truth, is it not applicable to physiology, to neurology, and even to psychology? For example: A patient, aged 52, upon whom rests heavy responsibilities, a highly trained civil engineer, cannot think and write at the same time. He can dictate to a stenographer thoughtful and planning letters, but to write the simplest business or even social letter requiring any intellectual attention or phrasing is absolutely impossible. He is under the necessity, therefore, in travel and at home, of having a stenographer about in order that he may answer letters, describe and attend to his work, etc. As a child, he was tortured for years to make him write with his right hand. The natural writing-center in the right cerebral hemisphere was thus rendered atrophic, crippled, or unusable, and the artificially stimulated mechan-

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ism in the left side of the brain could never be made to work correctly or easily by the other intellectual organs during the instant in which they had their own tasks to perform.

Another patient, a beautiful but sickly and also morbid-minded girl, never could go into society, to balls, dinners, etc., because she could never act naturally, dance, use the knife and fork unconsciously, or in any definite fashion; her eyes, brain, and body had been confused, made awkward and sickly, and her life had become a strange tragedy. The "ambidextral" tyrants had taken away from her, when a child, her natural lefthandedness; they had not made her righthanded; she could never, expertly or promptly, do the task or purpose desired; they had also given her lateral curvature of the spine and life-long indescribable misery.

In still another patient, although the tragical aspect had not been so noteworthy, there was found abundant interest in details. She is now lefthanded for all except writing. She also cannot write and think at the same time; indeed, she positively "hates to write," and must also dictate to a stenographer a simple description

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of her symptoms. She is a highly capable and educated woman, a famous teacher, and constantly addresses large audiences on pedagogical subjects with ease—except in regard to certain “slips of the tongue.” She frequently transposes words and even parts of words when speaking, immediately becoming conscious of the error and correcting it promptly. These transpositions began at the age of 13, after long and severe training (“with great agony”), had forced her to disuse the left hand for writing; she began asking for, or speaking of “mish and filk,” for instance, instead of “milk and fish.” Words with an opposite meaning are still used, as *warm* instead of *cool*. “West bay” instead of the intended “best way” will be uttered. If she has something in each hand she will lay down the wrong one, or throw that she wishes to keep in the waste-basket. The greater the general fatigue the more frequent such mistakes. Each eye is equally dominant, *i.e.*, the pencil throws two equally-clear images on the wall. At about the age of 17 she discovered that she could write with either hand, and synchronously with both, normal, or mirror-style, with one or with the other, etc. I append a

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series made recently to illustrate (pp. 128-145).*

In order to get a clear understanding of the teachings of the case I report, and of other similar ones, one must hold in mind several facts, and the most important is that there is no adequate knowledge of the significance of a biologic structure except historically. Secondly there is no history so exact and so illuminating as that given in the most comprehensive of all biologic laws, "the ontogeny repeats the phylogeny." That sentence is the master-key of almost all the mysteries of living things. The statical or anatomical phasing gets its explanation only through physiology, becomes clear only genetically. All pathology is in origin nothing more than aberrant and morbid physiology, and all organic structure is the product of precedent and repetitive function. There is no "pod" without a preceding pseudopod. Instead of the common scientific

* In all such bimanual writing it is to be noted that the pens were placed on the lineless blank sheets with gaze and attention, although the movements were subsequently executed without these guides. The spacial and topographic accuracy were thus better than would have been true under other conditions.

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nonsense that there is no inheritance of acquired characteristics, the truth is that there can be no inheritance of any characteristics except acquired ones. To come to details, the eye as an organic structure appears defined within a month after conception; the differentiation of muscular tissue only at five months; righthandedness (or lefthandedness), however, commences to appear only fourteen months after conception, *i.e.*, about five months after birth. If, therefore, the individual organism epitomizes and illustrates the history of all the ancestry, there are certain psychological and metaphysical conclusions which no monistic or other materialistic logic can escape. Embryologically, the eye is an extension of the brain; the brain comes out to see. It is not so of any other organ of the body. The eye precedes the appearance of muscular tissue by some four months; the inference is unavoidable that the perfection of visual function long antedates and conditions free motility, which is itself the condition of the existence of all higher organisms. *Ubi motus, ibi visus est.* That is the greatest of the Darwinian factors, strangely ignored by all Darwins, governing the survival

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of the fit and the exclusion of the unfit. A foreseeing and purposive planning of the mechanism of vision, and of motility, is thus evident, and there cannot be foresight and plan except there is a foreseer and a planner. Mentality, therefore, preceded and created structure. The mind, the life, the brain, the eye, made their tools.

Again, the appearance of slight righthandedness is five months after birth, and its perfectibility goes on throughout life. This particular differentiation of function is dependent upon attention, and is a matter of education. But there can be no attention without an attender. In sensation-making, in conscious willing to act, in choosing to use one hand rather than the other, we reach beyond the limit of automatonism or of mechanism *per se*, and come to the hand upon the lever of the engine, *i.e.*, upon the something beyond the machine—in a word, upon the metaphysical. If there is a control of force, called attention, that can be transferred from one side of the brain at will, and markedly change the functions of one side or the other, then there is something outside of and above the individual mechanisms and cen-

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ters which is not a part of them, and which uses them as tools. A player on the piano is something different from the piano itself. The player upon the cerebral piano transfers his attention to one side or other of the keyboard of the brain. The fact of attention, transferred at will to one part or another, and choosing at pleasure not only the music to play, but the parts of the keyboard on which to play, playing better with one hand or the other—all this demonstrates that there is a mechanism, a material, neurological mechanism, but also that the player is something other and different, placed over it, a mental somewhat not bound up with it, not explainable as the action of the nervous system *per se*, but using that mechanism as an instrument. The psychology that is monistic, that denies life, that denies the fundamental distinction and existence of a machine and a machinist, is *ab initio* unscientific.

Moreover, cerebral tumors and traumatisms and physiological experiment have absolutely proved that the adult, central, or cerebral mechanisms of memory, of language, of writing, of speech, etc., are located in one side of the brain, that opposite the writing hand. In the right-

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handed the left half-brain is therefore pre-eminently the seat of the mind. The mechanisms that give the man external validity, that intermediate him with useful objectivity, are one-sided. But this one-sided differentiation is acquired, and is subject to progressive perfection throughout life. The machine is becoming more and more perfect. Dividing the machine in two parts of the brain is degradation, is against progress, and the inevitable differentiation of function. "Ambidexterity"-mongering is the most absurd silliness.

Note that there is no discoverable difference of microscopic structure between the corresponding unused brain-tissue on one side, and that in the cerebral speech-center much used on the other. And note again that the choice is open to the attention or will to elect in infancy either side to work from, and thus to make the individual either righthanded or lefthanded. Observe also that as about 96 percent of people now are righthanded, the supposed "laws of heredity" are put utterly out of court so far as pertains to the number of the lefthanded. Every lefthanded person must have had millions of righthanded ancestors for every one that was lefthanded.

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Not to be omitted, too, is that with all the actual or possible education of the left cerebral center in the righthanded (or of the right in the lefthanded), there is a poorly co-operating observing or reversing, or mirroring mechanism of the other side which can be brought into use by the attention. The psyche is, therefore, again demonstrated to be something more than the mechanism. It plays at will upon the mechanism. It plays badly, if you please, but the mechanism does not play itself! Attention is merely the name we give the metaphysical player, the cerebral engine cannot run itself, or the piano play itself any more than could the locomotive or the musical machine. In depriving one hand or one center of the attention, we make the other an automatic "trailer" (as I have called it), working by means of the commissural fibers between the two oppositely-placed centers, but working badly, largely without the sense of direction, form, topography, etc. The attention, therefore, adds all-important elements to the mechanism. Psychology can no longer ignore pathology, or aberrant physiology.

Now, what is this "Attention"? As before,

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the question can be answered only genetically. The brain comes out to see, but only succeeds in really seeing with some comparative degree of accuracy at about five or six months after birth. *And this is precisely the date at which righthandedness, or the reverse, appears.* In about 96 percent of infants the right eye is the better-seeing eye, and thus compels the right hand to work with it. Thus, vision is the father of action, of righthanded action, and righteyedness is bound up as a precedent, synchronous, and causal factor of righthandedness. The writing illustrations to be given show that spacial relations are created and definitized by "ocular attention." Direction, location, measurement—all topographical factors, are thus products of vision. But a secondary product has been evolved, its working illustrated in the writing illustrations, which may be called psychic or mental attention. It is plainly a derivative or product of ocular attention because it can only exist separately when the visual attention is not upon a (usually) moving object. With the eye closed it may be brought into existence, but its derivative nature is again evidenced by its imperfection of work, the lack of direction,

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of accuracy of topographical qualities, etc. With the active vision renounced, it may even be turned upon sensations not visually derived, such as of sounds, odors, tastes, etc., but all sounds at least are topographical and directional; pain and touch are of the localized parts of the body, or again spacial in nature, and even taste is located in the mouth. The brain did not make out of its own substance the peripheral organs of hearing, taste, touch, etc.; the eye alone is brain-substance told off to a special mental and cerebral duty which was prevented by a nontransparent skull.

The execution of a compositely-formed resolve requiring first of all vision, then possibly other sensational stimuli, but always memory, *i.e.*, the stored results of all previous co-ordinated activities, words, speech, etc., can issue in swift and decisive act only through the placing of all the most directly intermediating cerebral centers in the closest possible contiguity in one side of the brain. If one is righthanded his centers for writing, speech, and memory must be on the left side. Upon the same side, therefore, must be the visual and other centers which furnish the chief data for the compositely-

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formed act. If one or more important data must come from centers in the opposite half-brain, delay at least must ensue, and other doubts and inaccuracies also. Hence the all-necessary concentrations of the chief organs and functions in one side of the brain. The organist plays on several banks of keys, and with pedals, uses scores of stops, reads five staves of music, etc., that is, he really plays on many organs at once. But his banks of keys and stops must not be located on different sides of the church, or even beyond the reach of his arms. The two cerebral cortical hemispheres are indeed somewhat connected by commissural fibers, but poorly so at best, as our trailing handwriting shows. Biologically, the safety and success of the human organism has always depended upon the most intimate, accurate, and swift co-ordination of many factors and cortical centers in order to issue in resolve and action. Such co-ordination could not take place if the cortical centers furnishing the necessary data for action were divided equally between the two cerebral hemispheres.

The difficulty of understanding the nature and origin of mirror-writing has come from the

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fact of looking at it as the result first of a pathological state of mind or nerve action, and secondly as the work of a finished or completed mechanism. Pathology has nothing to do with the matter; it is physiological and natural, due to the action and degree of attention, and it is also a product of education, habit, or development. Soltmann, Erlenmeyer, Marinesco, Sollier, and others look upon it as a pathological, and as a finished and presented fact. Others, Buchwald, Durand, Vogt, Nicolle and Halipré, Meige, Bernard, Ballet, Figuera, etc., hold it to be normal of the left hand in the righthanded, sometimes even in the lefthanded. In 77 deaf mutes Soltmann found 35 percent wrote mirror-style with the left, and he concludes that "the more educated the person the less he will fall into mirror-writing with the left hand." This is the reverse of the truth, and nothing is said as to the fundamental condition—the fact of precedent lefthandedness, either continued or overcome, and of mixed types.

A simple device would have put all such errors to rout and would have shown the truth. The difficulty in writing in the manner habitually chosen is forgotten; it is an art, slowly

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and laboriously acquired, and always poorly executed, this writing on a table or a flat surface in front, and with the body craned to the left to see with the right eye the writing which is being executed. (By the left eye in the left-handed, of course.) And also there is a universal neglect of the direction in which the hand is commanded to write. If one writes mirror-style he must write towards the body with the right hand, and away from it with the left. This is demonstrated by the plan here proposed: Place the surface upon which the writing is to be done upright—a solidly fixed sheet of plate-glass is best—the edge at right angles to the face and almost against the nose and forehead; attach sheets of quadrille paper upon either side by clamps. Thus is avoided the great difficulties the imagination and eyes have in projecting outward the image or seeing the writing which is being executed. The skewed, indirect, absurd-angled, reversed, and illogical writing posture is avoided, and the upright sheet of glass is as if the two-sided mirror were placed between the two cerebral halves. The writer should be one innocent of all such experiments, *i.e.*, not used to put his educated consciousness or atten-

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tion through any "tricks" or tasks; a pencil should be in each hand, the points on the sides opposite to each other. Neither eye can now be used if the pencils are started within a few inches of the eyes, so that the eyes may be closed, and the experiments will be all the better for the free working of the attention on the surfaces directly in front of the eyes. Synchronous writing under these circumstances will, in the righthanded, always show normal style with the right hand, and mirror-style with the left—or the reverse in the case of the untampered-with lefthanded. Fix the attention of the righthanded upon his lefthand writing, and command it to write normal, and compel the right to make some movements; it will make attempts at least, at mirror-style. The higher the expertness and mental culture the more certain will be such results. On the table before us vision, and that imagined vision we call central attention (with peripheral vision abrogated), controls or tries to control, but has so many difficulties that it has falsified and confused all experimentation. The left tries to write as does the right. My device removes confusing factors and conditions, and proves

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that everybody normally writes mirror-style with the trailing-hand, but dependent upon the all-controlling factor of the direction of the writing, and upon general education, imaginativeness, skill, habit, the development of central attention, etc. Sign-language, warfare, etc., first originated the habit of righteyedness and so of its resultant righthandedness, and this necessitated the location of the speech-center in the left half-brain. The particular incidence, now, in a certain child, of righthandedness or lefthandedness, depends upon which is the better seeing eye, when arm-and-hand motion arise and are co-ordinated with the function of the precedent and governing eye. Heredity has nothing to do with the matter directly, and only indirectly, in making the right eye the better seeing eye in infancy, and when the habit is established. In about 96 percent the right is the better seeing eye. If it is desired to make a lefthanded babe normally righthanded, the process must be begun in the earliest stages, and by means of giving the right eye the better function. This may now be held impossible, although atropine in the left eye of the child with beginning lefthandedness might possibly

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be efficacious. *Let no one attempt it!* Pathology follows almost inevitably any interference with Nature's institution of handedness, right or left, however early it may have begun. For the mixed type is far worse, and usually ends in more suffering than if lefthandedness were of the pure type.

In two-handed mirror-writing, and in the work of the trailing-hand, there is more than a suggestive hint, there is an intimate glance permitted into the mechanics of the construction or connections of the two-sided brain. It also comes out in the often-described experiment of writing with one, and then with the other hand upon paper while looking at the figure being made in a mirror set at right angles vertically in front. In a righthanded person the making of a square or triangle with the dextral hand is possible and comparatively easy, but on attempting the same trick with the sinistral hand, without forethought and quickly, the direction will be ludicrously reversed. Now, synchronous two-handed writing, by the righthanded, is easier and more commonly possible if the left writes mirror-style and the other normal style. The commissural fibers, the

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pattern-making threads, between the two opposed cerebral mechanisms, let us say between the two patterned or figured cloths, seem therefore to run from the "face," or "right" side of one, to the "back," "wrong," or "seamy" side of the other. Changing the analogy to that of two mirrors, the face of the mirror on one side of the brain reflects and normalizes the figure of the obverse or back side of the mirror on the opposite side of the brain. The mirror or cloth erected in the left-brain of the righthanded fronts consciousness and its figures are normal, while that in the trailing side is mirror-writing, or is the "seamy," "wrong" side of the cloth. In reference to the eyes, besides the evident facts termed righteyedness and left-eyedness, one of an equal or greater importance comes into view which I have called *dominance*. Usually and normally a righthanded person is righteyed, and a lefthanded one is lefteyed. That is, the right eye is normally the dominant one in the righthanded, and the left eye in the lefthanded. A simple test, one of many of dominance, is easily made and thoroughly convincing. Hold the pencil or finger upright a foot from the eyes in the median line and observe the

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image it makes on the opposite wall; closing the left eye results in no movement of the image on the wall, but closing the right or dominant eye throws the left eye into hitherto disused or non-selected function, and the image "jumps" suddenly to the right. The demonstration of the dominancy of the right is thus apparent; the mind must not be confused in action by two differently-placed images, and has learned to ignore the one and rely upon the other. And it ignores the least reliable and least accurate or useful image, which is the left in the dextral. Correspondingly, of course, the choice is reversed in the lefthanded person. And it is as evident that a high degree of ametropia, squint, amblyopia, or other disease, of the naturally dominant eye, would transfer the dominancy to the eye of the other side. In such cases the mind and entire organism is morbidized, decision and action are confused, delayed or inhibited reflexes are necessitated, stuttering and halting speech or thought appears, etc. This is because the right eye of the four-footed animalian phylum has controlled the motion and placing of the right front foot, guarded the right side of the body, etc., and primarily established the

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great law that co-operating cerebral centers must be in the same cerebral hemisphere to render decision and action the most exact and quick. Contiguity of these centers insures accuracy and celerity, while the location of one or more centers in the opposite hemisphere demands the intermediation of commissural nerves between the two halves, with which pathology arises. These morbid results are painfully evident in the sudden loss in adult life, of the dominant eye, or the more expert hand. To the observant they are equally evident in those naturally and healthily lefthanded persons made morbid by the morbid "ambidexterity" sillies. These persons put Nature to the foolish task of creating a second set of subdominant or equidominant cerebral centers where, according to God and common sense, one was not only sufficient, but infinitely better. In such cases the dominance of one eye is done away with and an equidominance or alternate dominance is established. Two images of the pencil on the wall are seen, and neither is unconsciously to be ignored.

Almost the sole method and means by which we come into large and intellectual relations

with the world are the results of vision. The total contributions of all the other senses compose but a fractional part of the ocular ones. Intellect itself is little more than epitomized ancestral visual experience. Nearly all our thinking is in images, pictures of things seen, and even the most scientific, even the most abstract and metaphysical intellectual processes are only seemingly amorphous; they are really like the crystalline coal-measures of ancestral and personal visual experiences. The difficulty is to draw the line between the inherited and the individual parts. The "*tabula rasa*" of the infant mind is by no means blank, but its inheritances are necessarily abstract, and are vivified and definitized by the daily millionfold personal, i.e., chiefly retinal, images poured among the ancestral carbon strata awaiting the touch of reality to awaken them to living light and heat. A truer analogy presents in language, the fused and packed epitome and record, the composite photograph, in fact, of racial experience. Nearer far to his personality than any other or all other products of Man's being here, the most immaterial, most spiritual record of his existence, is his language. And lan-

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guages are almost wholly the records of things seen. The greatest deed of mankind is the creation of the alphabet; so arduous was it in fact that only one alphabet has been evolved in and for the whole world. All are at one in the conclusion that this alphabet is the *sine qua non* of intellectual development and of the condition we call civilization. Well, the alphabet, as all know, is made up of the conventionalized pictures, ideographs, eye-made images and photographs of objective scenes and things. The seeing of things correctly is the foundation and condition of knowing things rightly and truly—*i.e.*, of civilized living and scientific thinking. Conversely, the seeing things badly and distortedly, *i.e.*, ametropically and with optic morbidity, is the source to-day of more suffering and improper living than all other pathogenetic factors combined. In all past time the composite of millions of ancestral visual experiences have been forming what we call mind, intellect, and memory. The elimination of the visually unfit has made the present-day heir of all the ages the product of predominatingly and relatively perfect eyes. Civilization adds an amazing acuteness to the present tragedy when

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an ametropic organism comes in bitterest personal clash with the inherited datum of all past experience. "Eyestrain" is thus usually the greatest misfortune which can happen to a civilized "near-worker." It morbidizes mind and body and is wrecking numberless lives all about us. Some day medicine will be aroused to the amazing reach of this awful truth, and in that day medicine, and especially psychiatry and neuropathology, will be revolutionized.

One may go further and say that not only is human life and civilization itself the quintessence of summarized visual experience, but the very development and evolution of biological forms above the lowest has been dependent upon vision. *Ubi motus ibi visus est* is the key of most higher organic evolution. Food and defense have always depended upon vision and perfection of vision, and the development of more perfect vision has been the forerunning means of the production of more perfect forms. The Darwinian exclusion of the unfit has been largely the exclusion of the visually unfit, and the survival of the fittest has been the survival of those possessing the best ocular mechanism. No task in organofaction has been so difficult of

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achievement and of healthy preservation as that of making the most perfect ocular mechanism.

One of the most inscrutable and important powers of the psyche is attention, but is it not almost entirely a product of visual function? In the congenitally blind and exaggeratedly ametropic the same truth comes to clearness. The inherited or epitomized experiences of the ancestry have operated in them, and in all of us, to beget the secondary and acquired kind of attention which we have in varying degree, and which may be called mental, intellectual, or central—that coming to view with deprivation of visual attention. It is inaccurate and imperfect, especially topographically, as our illustrations, even from a highly cultivated mind, show. The fundamental distinction has not been emphasized that visual attention depends largely and chiefly upon the following of the objectively moving thing with the eyes, or what amounts to the same thing, upon movements of the eyes to re-establish sensitiveness of the retina. Absolutely persistent gazing at an immovable point quickly results in inability to see it. The moving object rivets the attention, and so long as it is visually fixed mental or

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central attention and visual attention are fused into unity. There is no possibility, except possibly by training, of attentively observing a moving thing like the pen-point or the letters being made by it, while at the same time mutually and continuously attentive to another train of thought, memory, or objective happening. The bimanual writer may write the same letters and words synchronously, but not different words. This is simply because the eye cannot see different words being written. As all students have agreed, consciousness or attention is like a simple stream of sand passing through the constricted part of the hour-glass. The attention of an expert organ player, playing with feet, two hands, pulling stops, reading several lines of notes, varying the expression, etc., each second, seems almost to contradict the validity of the hour-glass comparison. It appears to be a widely spread-out rain of attention, different from the more primitive and naive or hour-glass kind of the rest of us. But even this is due, I believe, to an acquired ability of perceiving and acting upon the perimacular and more peripherally placed images of the retina. Most of us actually use and attend to the macular

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image, and the retina beyond is used only to call the attention of the eyes to an object not really or perfectly visualized and perceived, but which by ocular motion is at once brought upon the macula and then clearly perceived. Watching an organ-player read and play new music shows one that he has a staring and indefinite expression, which argues a large field of vision and attention, filled with many objects, all held in a synchronous, graded, and differing clearness of attention, impossible to do except after long education and practice. And this extension of visual attention to the images of the notes, keys, etc., located farther and farther beyond the macula, requires that they shall be visually and essentially correlated. The broadening of attention to multiple objects, the holding in synchronous unity seemingly discrete streams of objects and influences, seems, therefore, a matter of education, not of primary endowment, of progressive development and widening, instead of abrogation of the single-current, and depends primarily and wholly upon the ocular extension of the synchronous recognizability of correlated images falling farther than usual beyond the macula.

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The visual central (or mental) attention is separable from the peripheral visual attention only when peripheral visual attention is abrogated. That this central attention is derived from the visual, is its pale, possibly ludicrously inexact reflex, is apparent, even without the striking demonstrations shown in the writing illustrations given herewith. It is essentially of the nature of a *pis aller*, reminding one of the pathetic almost incoherent falsetto of the acquired speech of the deaf mute. By long cultivation it gains precision in the mind of the orator, musician, etc., but the extramacular education of the retinas lies at the foundation of the proficiency.

The origin of righthandedness and lefthandedness I have elsewhere set forth in detail, but must here epitomize. There is no reason to suspect even the most vague or far-away beginnings in animals. So long as the four feet are used for locomotion there could be no lateral differentiation of function. I have watched for it in squirrels that use their front paws to hold nuts, cats that strike at insects in the air, or play with wounded mice, and in many other animals, but I am sure that to neither paw is

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preference assigned. There is thus probably no dominancy of either eye in animals. Even in the monkeys and gorillas, who of all animals most use the forepaws as hands, one catches no suggestion of preferential use or superior expertness in the dextral or sinistral side. (My very intelligent dog, trained to "shake hands" with his right paw, lost his right eye, and after that he always offered the left paw.) But in the lowest human savages all over the world choice or greater expertness of one hand is as clearly present as in civilized races. No savages, however, are so near animalian conditions as to exhibit its differentiating origins. Fixed in all our military and social customs, and living at the base of language itself are two facts which solve the riddle and make clear whence and how righthandedness arose. In all tribes and countries since man used implements of offense and defence, the sinistral or cardiac side was protected by the shield and the sinistral hand was called the shield-hand, as the dextral was called the spear-hand. Next to fighting and synchronous with it was the need of barter, and the fundamental condition of bartering was counting with the low numbers, one to ten. The

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fingers of the free or dextral hand were of course first used, and all fingers are to-day called digits, as are the figures themselves, and the basis of our numberings is the decimal or ten-fingered system. The tally-stick, notched or numbered, is the record of the digits held in the air. Every drill and action of the soldier from Xenophon to West Point is dextral in every detail. The dominancy of the right eye is shown in firing from the right shoulder and sighting with the right eye. I have two patients, lefthanded in every respect, who have been taught to fire their guns from the right shoulder; but of course they are lefteyed, and they depress the right eye below the level of the gun, and sight with the dominant left eye. Rightfootedness, less differentiated of course, must follow righthandedness and righteyedness, so that all soldiers (and free masons, too) must step off with the left foot first, *i.e.*, the spring must be made with the right. The loss of the right hand, or right eye, mutilations, etc., very common in barbaric times, would help to account for the preservation of the present four percent of lefthanded people.

Because the underlying and governing condi-

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tion why the man must be generally dextral, or generally sinistral, is the evident necessity that the centers governing a co-ordinated set of functions, must be located in the same cerebral hemisphere. To make any important act precise, purposive, harmoniously, and rapidly effective, several interacting and fusing cerebral centers must conjoin their functions: Vision, the chief of all, must present the problem, determine the spacial or topographical relations, etc.; hearing, smell, taxis, etc., may or may not enter into the matter as auxiliaries; memory of past facts, stored chiefly in the same side of the brain, undoubtedly is called upon for other data (and memory is almost entirely a gallery of stored photographs made by the eye!)—then judgment and decision, working upon the data gathered from all subordinates, issues in the word which is the seal of volition, and in act which is reality or the incorporation of the psyche in objective sense and effect, in the materiality beyond cancellation or change. The essence of the matter is, therefore, were the chief of the contributing centers creating word and act divided between the two cerebral hemispheres, the certainty and celerity of the word

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and act would be lessened by the difficulty and delay consequent upon fusing the products of these remotely placed and poorly united centers. Hence the law that the better expertness of the chief dextral organs requires that the other co-operating organs, also more expert, must also be upon the dextral side. And vice versa of sinistral expertness. The centers of all organs contributing to the composite terminal act must be in the same cerebral hemisphere. All physiology and pathology show that the speech center, a single organ, can be and is located in only one side of the brain, sinistrocerebral in the righthanded, and that the hand which executes the writing act, the most intellectual of all acts, dominates the location of the speech-center in the opposite half-brain. The "ambidextral" societies, the mothers and school teachers, who would martyrize children naturally lefthanded by compelling them to learn an equal expertness of the right hand, are the most blunderful of stupid persons. No person ever was or ever can be made equally expert with both hands, and every attempt results in tragedy for the patient. To carry out the egregious plan thoroughly, flutes, half the

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violins, carpenters' and mechanics' tools, etc., and half the pianos should be made for the dextral "ambidextralists," and half for the sinistral "ambidextralists." All musicians should play half the time lefthanded and half righthanded on reversed piano keyboards, reversely strung violins, etc.; all carpenters and mechanics should work one day righthanded and the next lefthanded, with suitable tools; all soldiers drill lefthanded and leftfooted one day, and the reverse the ensuing day, etc., etc. What a world it would be if those who are wiser than God and Nature had their way!

Were it so, all laws and customs as to the "Rule of the Road" would have to be changed so that carriages, foot-passengers, etc., should pass half the time to the left and half to the right. All double-track railroads would then order trains to pass one day to the right and the next to the left, and their locomotive-engineers would then sit half the time on the right side of their cabs, and the other half on the left side. It took a whole generation time of experiments and mechanics to learn that the engineer must stand or sit on the right side of his engine or cab in order that he could look

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ahead with his right or dominant eye only, and without sticking his entire head out, as he would have to do if he sat or stood on the left side. The railroad men never learned why this is so, do not know why to-day, and to make the desirable change in three American left-passing double-track railroads, while it would finally avoid expense and accidents, would cost at once many millions of dollars. Thousands of years ago knights and men fighting on foot or horseback had to approach and pass each other on the left in order to strike or spear each other with the right hand while the shield-hand held the shield or the reins. The railway engineer, civil or locomotive, does not know that the knight was his righthanded and righteyed progenitor and endower.

A flood of light is thrown upon history, sociology, and medicine, especially upon psychology, neurology, and psychiatry, by lefthandedness and its sequels. Of every million born at least 30,000, probably more, are naturally lefthanded, so that in the United States there are nearly 3,000,000, and in the world over 45,000,000, thus handicapped. An indefinite proportion of these have been or are being

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doubly cursed by the efforts of the foolish parent or teachers to make them righthanded. Sad suggestions and illustrations of the baleful results of the work of these improvers of Nature exist in such simple facts as that *right*, which should mean only dextral or righthanded, has come to mean good, moral, advisable; and *left*, or sinistral, has become sinister, awkward, unlucky, to be avoided, both person and thing. *Dexterity* and *dextrousness*, properly meaning only *dextrality*, have become synonymous with expertness and exceptional proficiency, whereas everybody knows that the lefthanded person, if purely so, is as cunning of hand as the righthanded. Even the superstition of the "evil eye"—the nondominant one—teaches the same lesson. In all ages, and now surely, there are everywhere strange and unaccountable cases of "failure in life," "peculiar," "odd," "awkward" folk, cranks of a hundred types, misfits, stutterers, and all that. What a light the misplacement of the cerebral center for speech and writing, or its pernicious double placing and maleducation and crippling by "ambidextralists," throws upon the origin and fate of many stutterers, and upon many of the "hopelessly

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stupid," the laggards in school! How many of the medieval court jesters and the derided, the town-fools, the kyphotics, and cripples were the products of the "sinister" superstition of the righthanded tyrants? And how many of the morbid-minded and insane?

Incidental and accidental results of the study of these cases would solve many problems and mysteries of medicine, and surely of psychology. Pathology is physiology gone astray. The thorough-going study of individual cases of aberrant neurology will be found to illumine many of the dark places of mental and moral genesis, function and law.

Abraham Lincoln¹⁷

1aL.

Abraham Lincoln²⁹

1aR.

No. 1aL and No. 1aR illustrate the natural ordinary single-hand, or discrete, writing, each made under the influence of the visual (which

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also includes the central, mental, or intellectual) attention. In each case the writing is equally clear, equally respecting the laws of symmetry, and equally correct in topography, direction, localization in space, etc. The slant of the letters, a visual result, is in each case that common in dextromanual writers, and in sinistromanual writers. It should be borne in attention that these slantings of the individual letters are in occidental nations dictated by visual function and, when unconscious, are always present; they are preserved even in the most peculiar or abnormal of the tests to follow. The origins of these slants I have set forth elsewhere. Noteworthy in the illustrations above is the fact that the sinistromanual writing does not fill the allotted 3 3-8 in., but is condensed laterally, not vertically, so that relatively the object occupies only about three-fourths of the longitudinal space taken by the dextromanual writing. It must not be forgotten that the "patient" or "subject" was congenitally lefthanded, but by practice and lifelong habit a dextromanual writer. The preservation, under these circumstances, of a sinistromanual proficiency equal to that of the dextromanual is significant, both for

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the neurologist and for the "ambidexterity" societies.

Abraham Lincoln ^{2.3}
1bL

Abraham Lincoln ^{2.5}
1bR.

No. 1bL and No. 1bR, also written separately with closed eyes, bring out the effects of the absence of visual attention. Central attention alone appears to be at best a somewhat vague and inaccurate representation and product of visual attention, yielding want of sense of direction (slanting of the left line upward, of the right downward to an equal degree), and relatively equal inaccuracies in the forms of individual letters in both samples. That the topographic or spacial sense is the direct product of visual attention is again suggested by the fact that, without its aid, the central attention reverses the result seen in 1aL and 1aR, as to filling of the allotted longitudinal or

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lateral space. With the left hand (right cerebral center) it fills the entire space, with the right hand (left cerebral center) only about three-fourths is occupied. Lack of the influence of the acquired and inherited visual attention has therefore generally an effect in laterally contracting the space-content in the acquired dextromanual habit, and correspondingly enlarging that of the congenital and disused sinistromanual habit. The inheritance of spacial sense of all past ancestors requires the instant's influence, in the act, of visual attention to insure the best accuracy.

Abraham Lincoln 20

2aL

Abraham Lincoln 21

2aR

No. 2aL and No. 2aR are synchronous writings, under the influence of visual attention (which includes central attention) upon the forms made by the dextral hand. The sinistral is here the hand of nonattention; let us call it

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The Trailing Hand. Although for writing it is the life-long habitually disused hand, it was the one first used and habited in writing, and its central mechanism in the right cerebral half-brain has preserved perfection of function, despite disuse, and "trails" more perfectly than the dextral in the next example, 2*b*R. The lateral space is again less completely filled by the sinistral hand, although it is the "trailer."

Abraham Lincoln ¹⁸
2*c*Z

Abraham Lincoln ²³
2*c*R.

No. 2*b*L and No. 2*b*R were written under the same conditions as No. 2*a*L and No. 2*a*R, *i.e.*, synchronously without visual attention, but with visual and central attention fixed upon the sinistral movements, the dextral hand being the trailer. The sinistral space again is not filled; the accuracy and perfection of the writing of the sinistral is a little better than in No. 2*a*L, but the noteworthy fact appears that al-

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though the central mechanism of the dextral hand has been the life-long habitually functional one, its natural repugnance, unfitness, etc., is shown when it is deprived of the factor of visual and central attention, the individual letters being generally slovenly formed, the *i* not dotted, etc. It trails worse than the sinistral despite its education.

Abraham Lincoln 22
2cL.

Abraham Lincoln 23
2cR.

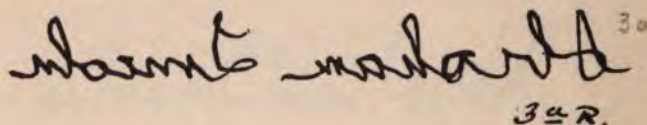
Abraham Lincoln 25
2dL

Abraham Lincoln 27
2dR

The effect of depriving synchronous bilateral writing of visual attention is shown in 2cL, 2cR, 2dL, and 2dR. In the 2c series central atten-

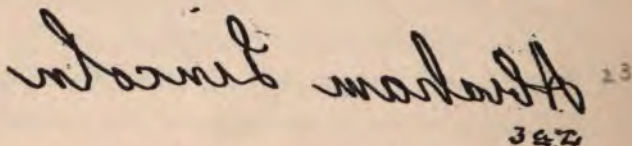
RIGHTHANDEDNESS AND LEFTHANDEDNESS

tion was fixed upon the dextromanual movements, the sinistral hand being the trailer. In the 2*d* series the central attention is fixed upon the sinistromanual movements, the dextral hand becoming the trailer. In both cases the sinistral writing is the more condensed laterally. The effect of synchronously carrying on the bilateral movements (without visual attention and only with mental attention) is not so bad upon the sinistral as upon the dextral writing, even when the sinistral is the trailer and the dextral has the advantage of central attention. No amount of habit or usage abrogates the primal trend towards lefthandedness or makes the acquired writing expertness of the dextral hand equal to it.



3a

3a2



3b

3a2

Series 3 further illustrates the general laws already observed by the condition of mirror-writing. No. 3*a* shows the ability of this sub-

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ject to write with either hand, alone, and with visual attention directed to the movements. By looking through the paper, back to the eyes, or by the use of a hand mirror, one sees that the mirroring or reversing of the dextral hand is less perfectly and correctly done than with the sinistral mechanism. The subject says of this that with the sinistral hand the reversal is "done easily, rapidly, and automatically," while with the dextral hand it is carried out "with difficulty and slowly."

262 *Handwritten cursive text, possibly "Handwritten" and "mirrored"* 19

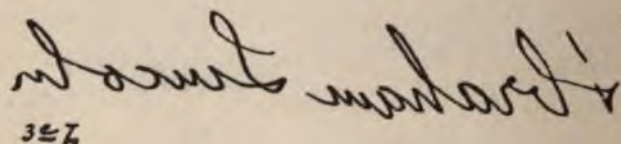
Handwritten cursive text, possibly "Handwritten" and "mirrored" 25

362

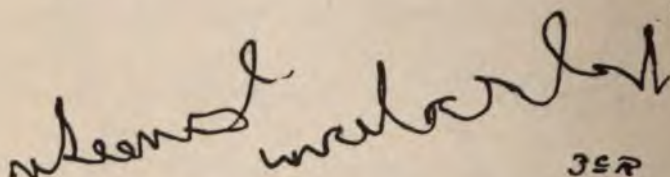
The effect of the deprivation of visual attention upon mirror-writing shown in 3b series further illustrates the foregoing suggestions. Each is written separately, and by the aid of

RIGHTHANDEDNESS AND LEFTHANDEDNESS

central attention only. "The right reverses just as badly" as in the case immediately preceding. The sinistral hand does its work far better than the dextral under the disadvantage, and the comparative loss of the sense of direction and space-relation is strikingly manifest. For the first time is shown the tendency, slight in the sinistral hand, marked in the dextral, towards a declination, and a double one, of the two words, from the right to the left, *i.e.*, in the direction in which the mirror writing proceeds. The sinistral writing is again the more condensed.



25
357



25
357

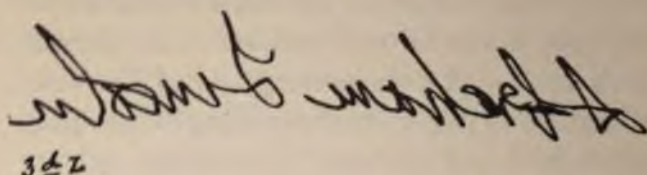
The complications of the problem, as well as of the interest, increase in the remarkable (unique?) ability of this subject to execute mirror-writing with both hands synchronously.

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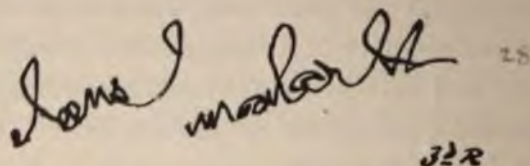
The results are shown in 3cL and 3cR, written with the visual (and central) attention fixed upon the movements of the sinistromanual pen. The trailing dextral is the worst so far in all respects—either as to formation of the letters, declination, and even overlapping of the lines from right to left, and overrunning of the space both lateral and vertical. The topographic or space-limits are little recognized or observed, and character or individuality of the writing is lost. But here arises the most noteworthy and significant statement of the subject: “I find that I cannot execute what would be the logically preceding series, *i.e.*, when the mind is fixed upon the right-hand movements. *They will not go.*” Nature flatly balked and refused to budge. Motion was entirely inhibited with the attempt at two-handed mirror writing when visual attention was fixed upon the dextromanual movements. Such writing could only be carried out when the dextral was the trailing-hand. In this case there was, therefore, sufficient perfection of the dextromanual mechanism to trail, that is, to act, and badly, as an automaton, by the aid of the more perfect, though disused initiative of the sinistromanual one.

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To initiate was impossible when it had to supply subordinate directing force and control to the trailing sinistral hand.



3dL

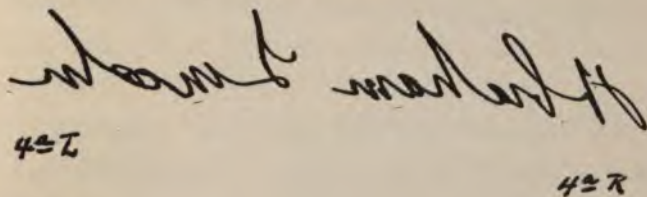


3dR 25

When deprived of visual attention by the aid of central attention alone, synchronous mirror-writing, with both hands, again repeats and accentuates the preceding conclusions. This is shown in 3dL and 3dR. Again the central attention is fixed upon the left-hand movements; the right is still able to trail, but notice the lateral concentration of the two words deprived of the control of visual attention, the degradation of form of all the letters, almost to indecipherability, the sharp declination of the line-direction from the dextral to the sinistral side, etc. The space-sense or topographic conscious-

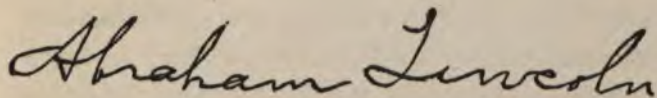
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ness is nearly lost. The trailing has become so inaccurate and wretched as to be denominated vagrancy. And of course with mental or central attention only fixed upon the dextromanual task there is even a more absolute impossibility than in series 3c of executing any legible or orderly movements whatsoever. "They will not go." But even when deprived of visual attention the central attention upon the sinistral hand is able to make fair copy, and to do much toward helping out the trailing dextral. No amount of use and education could give the dextral mechanism the initiative and effectiveness retained by the thirty-five-year-long disused sinistrocerebral centers.



42L

42R

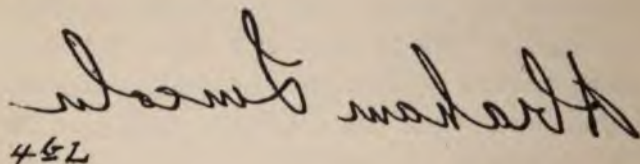


Abraham Lincoln

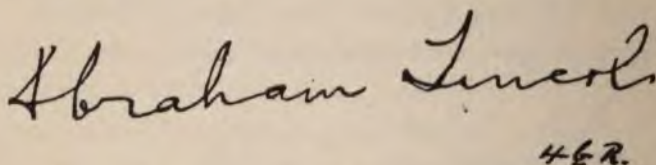
The task remained of writing synchronously with both hands, normal style with one hand,

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mirror style with the other. No. 4aL and No. 4aR is the first illustration, made with visual attention fixed upon the dextromanual movements. In this case the dextral hand writes normal style, the sinistral mirror style. The trailing sinistral line climbs a little as it moves onward, but the character, accuracy, etc., are well preserved in both.



Abraham Lincoln
45L



Abraham Lincoln
45R.

In Nos. 4bL and 4bR the visual attention is fixed upon the sinistral hand; the dextromanual writing is in normal style, the sinistromanual in mirror style. The writings are synchronously executed. That of the dextral hand is more inco-ordinate, tends still more than before to overrun the lateral limits, ascends as it proceeds, etc., but both are easily legible. The

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superior initiative and controlling power of the dextrocerebral mechanism is re-exemplified.

4cL — *John G. Marshall*

Abraham Lincoln

4cR

Nos. 4cL and 4cR repeat Nos. 4aL and 4aR, with the exception that the movements are deprived of the guidance and control of visual attention. The tasks are synchronous, of both hands, and the central attention in this instance is fixed upon the movements of the dextromanual pen. The dextral hand leads and writes normal style, the sinistral trails and writes mirror style. Both lines decline from a horizontal somewhat as they proceed. Although the mental attention is upon the dextromanual movements, the sinistral hand restricts its work to normal and usual lateral limits, while the difficulty of its task, in originating and con-

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trolling the trailer, seems to make the dextral lose the sense of space limits heretofore observed. But even here the legibility of the writing of the sinistromanual trailer is well preserved.

42Z
Abraham Lincoln

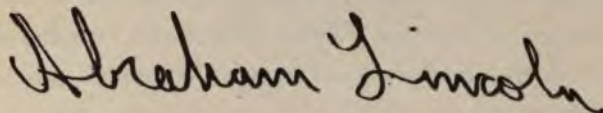
Abraham Lincoln
42R

In Nos. 4dL and 4dR the conditions of the last test are observed, except that the central attention is fixed upon the sinistromanual movements. The level of the lines is better kept; legibility of both writings is good; the lateral limits of space are preserved or exceeded in the same way as in 4cL and 4cR.

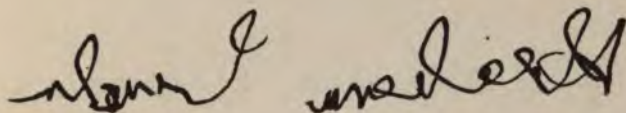
In Nos. 5aL and 5aR the sinistral hand writes normal style and the dextral writes mirror style synchronously. Visual attention is permitted and fixes the sinistromanual movements, which climb a little, but which result is legible writing.

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But the associated ones of the trailing dextral hand become almost illegible and have lost nearly all sense of orderly topographic consciousness. As in the 3c series the subject again explains that "it will not go with the visual attention fixed on the right-hand movements." The stint was found impossible. And



J=Z



J=R

of the greatest significance is the further statement that "this form of reversal was always the least satisfactory, and is not now so good as it used to be." Later, upon request, Miss K. writes: "Some time before I was twenty I discovered that I could do this reverse writing, and since then I have occasionally amused my friends by doing it, but very seldom. Until I did this for you it is surely five years since

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I last tried it. I did not notice the inability to do this particular specimen less well until I tried it this time for you. I have no specimens written in the past." The co-ordination of the two cerebral hemispheres is therefore losing an acquired function or aspect, and reverting to a desirable and natural singleness or monolaterality. Confusion, awkwardness, inhibition, indecision, or imperfection of function must follow decision or action initiated or controlled by centers co-operating from different sides of the cerebrum.

Abraham Lincoln
55L

Abraham Lincoln
55R

The limit of illegibility and loss of the sense of spacial relations is shown in Nos. 5bL and 5bR, written under the conditions imposed in 5a, except that the sinistromanual movements

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were deprived of the help of visual attention. Of course it was again wholly impossible to write anything whatever when the mental attention was fixed upon the dextromanual writing movements.

CHAPTER V.

VISUAL FUNCTION THE CAUSE OF SLANTED HAND- WRITING; ITS RELATION TO SCHOOL HYGIENE, SCHOOL DESKS, MALPOSTURE, SPINAL CURVATURE, AND MYOPIA.*

Slanted Handwriting is Bad, but not because of Bad Reasons.—Careful and trustworthy statistics show that on the average 27 percent of the pupils in the primary grades of the schools of Europe have lateral spinal curvature. The fact is as terrifying as the greatest in pathology, as bad, for instance, as the prevalence of tuberculosis. There is no reason to doubt that American children are less scoliotic than those of Lausanne, Dresden, etc. If not actually crying out against slanted handwriting and school-desks as the causes of this appalling disease, almost all orthopedists and school hygienists admit or suggest it. And yet slant handwriting is not only not the cause of the writing malposture and of scoliosis, it is only a minor effect of the writing malposture. It is

* Medical Record, April 22, 1905; Biographic Clinics, Vol. iii.

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not only an effect, but, bad as it is, it is a method of avoiding worse malposture. To no one could such a style of writing be more repulsive than to me, and yet, as one must so often emphasize, the bad reason does not make it bad. The reasons for vertical *vs.* slanted handwriting must be scientific and true or the slanting will never be done away with. There are considerations very different, and of infinitely more importance than the slanting itself, why such writing must be abolished.

Factors of the Writing Malposture.—All acts or habits are wrong some of the time, and some acts or habits are partly wrong all of the time. Only the act of writing, as commonly carried out, is wholly wrong all the time.

1. In a state of rest every object illustrates and obeys the law of gravity, equilibrium, or architecture, which demands that its center of gravity must be vertically above its base or point of support. A feeling of strain or irritation arises in the mind when natural objects do not conform to this law. Tumbling-down chirography does not obey this law.

2. The letters of the alphabet are conventionalized pictures or ideograms of the pictograms

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or pictures of natural objects—the ox, horse, camel, door, window, hook, serpent, hand, fish, water, eye, mouth, head, etc. These prototypes, of course, obeyed the law of gravity in Phœnician and Semitic times as they do now. The modern written letters of the alphabet should do the same.

3. All printed and type-written letters and musical notes preserve the erect position. The handmade letters should conform to the rule.

4. The slant method of writing is a result of the writer's personal difficulties, but the character of the writing is, or should be, dictated by the consideration of the reader's sake, not because of the writer's personal or pathologic trouble.

5. More important than all the foregoing is the fact that the vast majority of all persons have some astigmatism, and about 95 percent of all astigmatisms are at or about the axes 90° and 180° , and such eyes demand the prevailing lines of things seen at 90° or 180° .

Even if no astigmatism is present, or if that which is present is not in the neighborhood of 90° or 180° , the habit of equilibrium, and the inheritance from all ancestors of the habit of

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holding the head erect and of seeing with the eyes coincident with the usual 90° and 180° axes, would compel the customary position.

The secondary factors, which determine the posture and malposture of the body, and the character of the handwriting, vertical, slanted, or otherwise improper, are:

1. The position or posture of the head.
2. The position or posture of the body.
3. The location of the paper upon the desk.
4. The angling or skewing of the paper as regards the right angles of the desk top or writing board.
5. The flatness or inclination of the desk top or writing board.
6. The relative height and distance apart of the desk and seat.
7. The position of the hand, method of holding the penholder, etc.
8. The necessity of parallelism between the vertical axis of the head, or what is the same thing, of the 90° axes of astigmatism of the eyes, and the vertical lines, real, supposed, or presented by the formed lines of the written letters.
9. The relative position of the right or domi-

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nant eye, and the unhindered meeting of the visual axes of both eyes, upon what may be called the writing-field, *i.e.*, the space at and about the pen-point.

Briefly epitomized, this etiologic factor arises from a bending of the head to the left, skewing of the paper, etc., in writing, in order that both eyes of the writer may have a clear view of the writing-field or space about the pen-point. And especially by the right or dominant eye, the one corresponding in function, and particularly in writing, with the righthandedness (expertness) of the righthanded person. This canting of the head to the left produces a functional cervical curve with the convexity to the right, which I suggest is the primary factor in the formation of subsequent compensation curves of the spine below. Orthopedists seem to have forgotten that the cervical vertebrae are part of the spinal column; any lateral bending of any part of the column produces twisting or rotation, with the production of reverse or secondary curves later, in the effort at compensation. George Sand and all the advocates of vertical handwriting have persistently demanded *Ecriture droite, sur papier droit, corps droit*—vertical handwriting,



FIG. 1—The hand in the writing posture as usually ordered but not practiced, because to the writer the writing-field is hidden by the thumb, finger, and holder. View of an actual hand with the writer's head displaced.

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on vertical paper, the body also vertical. Knowing what was and is intended by the words, not what literally is said, we may add that even this intended advice is impossible of execution. No righthanded person ever writes so, or could write so, *i.e.*, if the paper (as supposed) is horizontal, placed squarely (not skewed) before the median line of the body, and the penholder held as instructed in the "correct position," *i.e.*, with the upper end pointing toward the shoulder. No one ever wrote a line in this position, and simply because he could not see the letters he was making. And to write we must see the letters which are being formed. (See Fig. 1.)

Details as to the Nine Factors of Malposture in Writing.—

1. The position of the head may be:

a. Perfectly erect, its long or vertical axis corresponding with the vertebral axis when the body is erect and accurately and squarely in front of the desk.

b. Canted or tilted to one side, to the left in the righthanded, and in various degrees.

c. Twisted on the vertical axis of the head and neck, to the right in writing, by the righthanded.

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d. Positions *a* and *c*, combined or mixed.

e. Positions *b* and *c*, combined or mixed.

2. The posture of the body may be:

f. Erect, the lateral axis parallel with the front line of the desk.

g. Bent to the left (in the righthanded) in varying degrees, the vertebral column being either straight or curved.

h. The spinal column twisted in varying degrees.

i. The right side of the body turned toward the desk or approximated to it more or less.

j. Varying combinations of the positions *g*, *h*, and *i*.

In practical and unconscious writing the positions of the head and postures of the body above enumerated under 1 and 2 may be and usually are mixed and interdependent, thus resulting in many modifications and variations.

3 and 4. The location and angling of the paper upon the desk may be:

k. In front of the face and squarely placed, *i.e.*, its lower border parallel with the front of the desk.

l. Askew, at varying angles to the left, but usually at an angle of about 35° with the desk front.

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m. With the lefthand border parallel with the desk front.

n. Opposite the right shoulder in head and body postures *a* and *f*, the lower border parallel with the desk front.

With the ordinary straight penholder and pen held as universally ordered, and the head and body in postures *a* and *f*, no ordinary human being can write, because the index finger and the pen necessarily come between the right eye and the pen-point. (Fig. 1.) Therefore, every writer immediately disobeys the teacher and varies one or all of the positions, postures, etc., so that the dominant eye has an unobstructed view of the writing-field. (Fig. 2.) The most extreme position of the body and head I have ever seen was in a patient who had an enormous astigmatism, and who was compelled to bring the eyes almost to a level of the table, with extreme rotation of the head in order to bring the astigmatic axes into parallelism with the lines of the writing being executed. Position *n* of the paper is the only one that permits of the perfectly erect or hygienic postures of the head and body designated as *a* and *f*, because only under such conditions can the dominant

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eye have a clear view of the writing field.

5. But the difficulty of writing in these postures and conditions is greatly increased by the flat desk, and is almost done away with by an inclination of the desk leaf or writing board at an angle of 30° . The ink will still flow from the pen with the leaf at this angle, the position of the head and body made most comfortable and hygienic, and the unconscious tendency to bend the head and body is neutralized. The copyists and monks of medieval and Latin times learned this, as is illustrated by the annexed cut. (Fig. 3.) An added and highly important consideration is that by the 30° or 40° sloped desk leaf, the eyes are enabled to look off at the book or writing at nearly a horizontal line, instead of down upon it with the eyes nearly vertically over the letters. The traction on the inferior recti muscles of the eyes with the resultant unnatural position of the eyes, is a prolific source of eyestrain. It also compresses the chest, humps the back, interferes with the circulation of the neck, the supply of blood to the brain, and the flow of air in and out of the lungs in breathing. The inclination of the desk may be more pitched in reading than in writing.



FIG. 2—The common but in the picture somewhat exaggerated writing malposture method of holding the pen, skewing the paper, bending of body, torsion of head, etc., in order to gain a clearer view of the writing-field.

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o. The child's feet must rest lightly and naturally upon the floor, with the knees bent at about a right angle, the body at the proper distance from the edge of the desk. This can be effected



FIG. 3—The medieval copyists wrote with the paper pitched at a sharp angle.

only by means of a seat that may be raised or depressed, and not attached to the floor.

6. The organizers, teachers, trustees, furniture makers, and parents have too often failed to notice that children differ in height from

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adults, differ from each other, and that they have a habit of growing. Even the most progressive in very recent years have not come to a thorough-going knowledge of these simple facts, and have not made the school desks and seats to conform accurately to them. What is now needed is mechanical constructions which will meet the differences of each child in an easy and perfect manner.

p. The leaf of the desk, in addition to being inclined at an angle of about 30° , must be of a height which brings the printed book and writing paper at a distance of about 14 inches from the eyes.

q. The pedagogs have also usually failed to notice that in reading a book it may be placed opposite the median line of the body or face (in erect position), but that in writing the paper should not be thus placed. Hence the frequent permission in writing to turn the right side of the body toward the desk. When the paper is placed opposite the right shoulder upon a sharply-inclined desk leaf of the proper height, the eyes can see the writing-field without unnatural positions of the body and head.

7. Everyone has probably wondered why,



FIG. 4.—The usual writing posture. The body and head are bent to the left, the head in addition rotated so that the chin is to the right; there is a cervical curve with the convexity to the right; the right side of the body is turned toward the desk; the paper is skewed to the left; the predominant 90° axes of astigmatism, aa , are at approximate right angles to the vertical lines of the paper, aa ; to lessen the strain upon the body, neck and eyes, the approximate parallelism of the lines cb , with the lines aa , of the skewed paper is varied, causing the obliquity of the written letters to the right, or the slanted style of handwriting.

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when the school and writing teacher are ignored or forgotten, the pen and holder are either slanted differently; held between the first and second fingers; not seldom angled parallel with the lateral lines of the paper, even nearly vertical, or toward the upright lines of the paper; drawn inward and toward the chest, the eyes above and looking down vertically upon the sheet; and the head in various other unnatural and cramping positions. (Fig. 4.) Such anomalies are too frequent to be called anomalies, and are simply the unconscious morbid methods whereby the dominant eye gets a free view of the writing-field. The types of this unhygienic pen-holding are too numerous and anomalous to be classified.

Artists, by means of long-handled brushes, etc., are able to gain a clear view of large spaces about the point of the brush, pencil, etc., by grasping the handle several inches from the point. They are thus under no necessity of inclining the head and body. Also their canvases, easels, etc., are either vertical or nearly so, and this does away with the visual difficulty encountered when the surface is horizontal or only slightly inclined.

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8. Some authors describe postures in which the body is leaned to the right, but they are not practiced because the writing-field is thus hid-



FIG. 5—A malposture pictured and described by authors, but never practiced by one in writing, because the writing-field would not be visible. The artist unconsciously shows the cervical curve with convexity to the right, almost always present in dextral writers.

den to a greater degree. (Figs. 5, 6, 7, 8, 9, 10.) In all the multitude of improper postures, positions, pen-holdings, etc., the teachers of writing, hygiene, and physiology have failed to notice that by some device nature will bring it



FIG. 6—Some hygienists describe a form of malposture consisting in skewing the paper to the right and bending the body and head to the right; it is never practiced because the writing-field is still more hidden than in the posture of Fig. 3 ordered as "correct."



FIG. 7—View of the writing-field as seen by the writer with skewed paper, and with the body and head turned to the left.



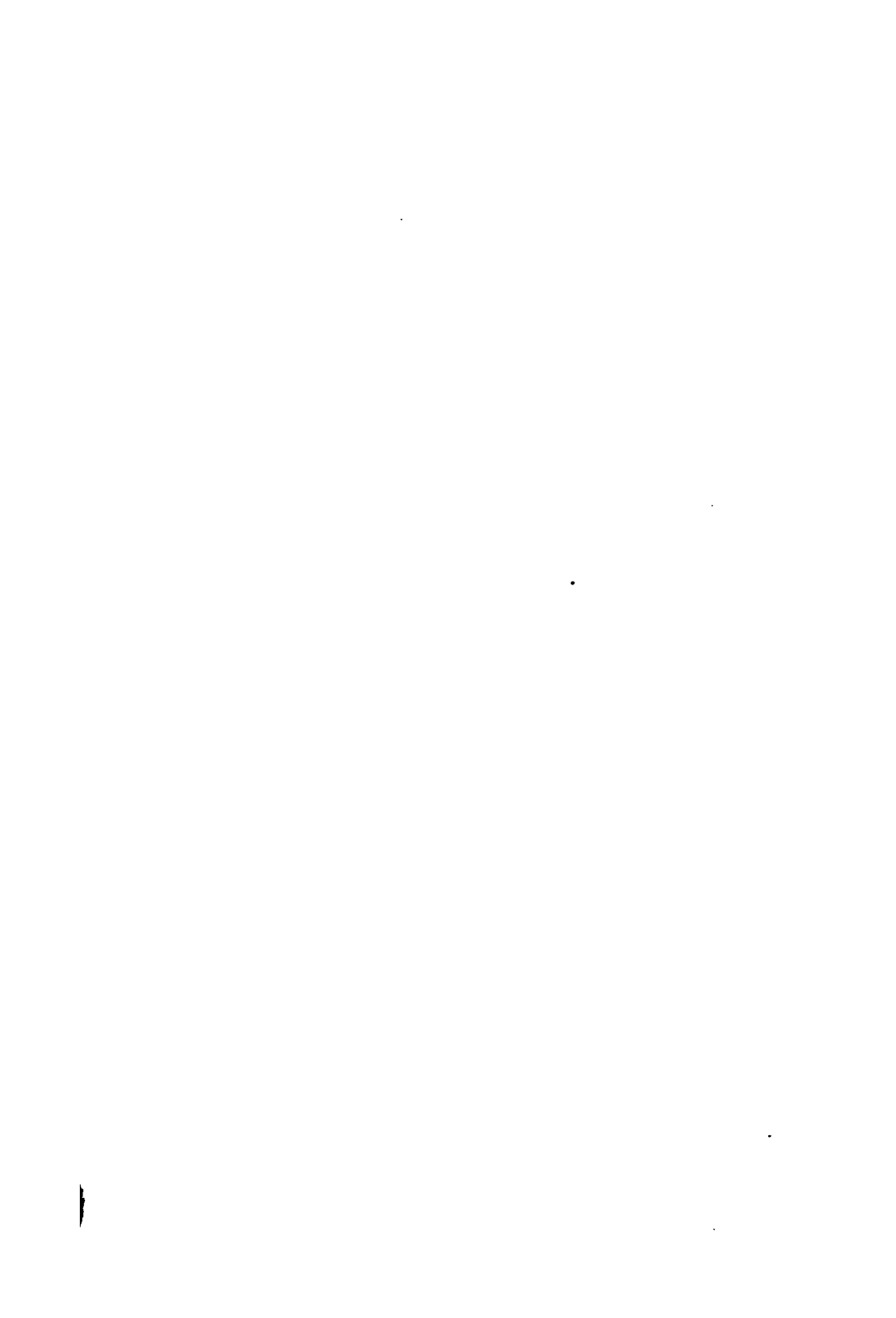
FIG. 8—To gain a better view of the writing-field the pupil instead of leaning to the left, sometimes bends forward until the eyes are directly above or even in advance, of the writing, lateral curvature and rotation of the spine being thus avoided.



FIG. 9—The writing-field brought into clear view by holding the penholder between the first and second finger, thus lessening the need of bending the body or head to the left. The view is as the writer sees it, his head being out of the field in order to photograph the hand.



FIG. 10—To secure a better view of the writing-field the hand is held in a straining and unnatural position, the holder directed 90° to the right of the right shoulder.



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about that the 90° axes of the eyes and astigmatism will be forced into parallelism with the vertical or slanted lines of the long letters being written. Hence the multiplicity of morbid postures begotten by the failure to place the paper properly before the right shoulder and with the head and body erect, with the inclined desk leaf, and the penholder properly seized.

9. Only when these conditions last named are assured has the dominant eye an unobstructed view of the writing-field, at the proper distances, etc. To secure this clear view of the writing-field with the paper placed according to universal instruction, the head and body are forced into unnatural positions. The unnaturalness and weariness of these morbid postures are lessened a little by the slanting of the letters to the right, and the tendency of the line of writing to slant upward. This any one can demonstrate by a few thoughtful tests or observations. And this is the source of slanted handwriting. (Fig. 4.) It is in fact a method of avoiding still more extreme torsion of the head or neck—a greater morbid slant of the patient by a slant of the writing.

I cannot find that anyone who has written of

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handwriting or of school hygiene or who has instructed or advised as to the making of school books and seats, has ever dreamed of the latent and easily recognized fact that every one of the nine factors are verities, and that they are bound together into a co-ordinate unity. None of them can be much changed without changing all of the others, and unconsciously every pupil and writer has solved the problem of carrying out the writing act by a special and personal adaptation and modification of each of the factors mentioned. The one all-dominating necessity which everyone discussing the subject seems to have overlooked, is that the writing field (the space about the pen-point) shall be seen, seen with both eyes, but especially seen with the right eye. I speak of righthanded and righteyed persons. All is reversed as to the lefthanded and lefteyed. The essence of the matter is the necessity of binocularity and especially the existence of a righteyedness, a hitherto unrecognized thing, and the most intimate co-ordination of the right eye and right hand in the most mental and intellectual of all acts, except speech—that is, writing. The positions usually taught by school teachers, writing



FIG. 11—The normal or hygienic posture of the body and head with the paper placed vertically and opposite the right shoulder. The arm and head thus have free motion. There is some constraint, due to the flat desk, a too great distance of the writing, and the fact that the visual axes, falling at an angle of about 45° , demand a bending of the head forwards, or too great traction on the depressor muscles of the eyes.



Fig. 12—With the desk-leaf pitched at an angle of 30° or 40°, the posture is hygienically perfect, and the faults of Fig. 6 are entirely avoided.

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teachers, and copy-books are next to impossible, certainly not practised by the child or man when writing much or unconsciously. Then nature modifies all the nine factors mentioned, solely and simply in order that the hand, fingers, and pen shall not come between the right eye and the writing-field. The pathology of school life in a multitude of symptoms and diseases consists for the greater part in the unhygienic attempts to see the writing-field with the dominant eye. And the two great blunders of all the teachers and desk-makers are that the pen-holders and pens are not shaped so that the writing space or field about the pen-point can be seen with both eyes when the body and head are erect; or that the desk is not inclined at an angle of about 30° , and the writing paper is not placed squarely and opposite the right shoulder, with the body and head erect and squarely postured before the desk. With the paper so placed the desk top so inclined, the body and head thus erect, the right eye sees the paper at 12 inches or 14 inches, and the writing is vertical. (Fig. 11, 12.)

Probably as many as 200 distinct styles of school desks and chairs have been proposed,

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tried, and rejected or are in use. The reader may find some of these described in works on school hygiene, such as that of Kotelmann, Meyer, Staffel, Fahrner, Rettig, Hermann, Bendzula, Schildback, Schenk, Hippauf, Prausek, Wallraff, Barnard, Priestly Smith, Stone,* Shaw,† and especially Risley.‡

So far as these relate to reading of a single book the results reached by students of pedagogy are of great value—but with one exception: All advise an inclination of only 10° or 15° . It should be at least 30° , and with easily made devices for holding the book should be 45° . Even with the 30° inclination the pupil will often hold the book with the hand at a greater inclination, and there is no reason why every desk should not be inclined at least 30° . When two books are used at one time, or when the pen or pencil is used synchronously with reading, the inclination must be greater than 15° , in order to permit hygienic posture. In the writing act hygienic posture is almost impossible with less than a 30° pitch. This fact,

* American Physical Education Review, June, 1900.

† Ibid., June, 1901.

‡ Norris and Oliver: "System of Disease of the Eye," Vol. ii.

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together with insufficient space at the right, largely vitiates all previous results, decisions, and mechanisms as regards school-desks. The simple device needed is one which will permit a varying and independent pitch of the two vertical halves of the desk itself. It should be possible to give either any pitch between 15° and 45° , and with devices so that the book, slate, paper pad, etc., will not fall, and may be held in place without the hand. If the pencil is used, even as high a pitch as 40° or 45° will be grateful to the body and eye. If ink is used, the pitch should be at least 30° , as with this inclination the ink will still flow, and only with so high a pitch is there possible a view of the writing-field with the right eye and at 14 inches distance, when the paper is placed opposite the right shoulder, with the head and body erect, without elevation of the right shoulder; this insures free motion of the right arm and hand in unconstrained and normal positions. The copyists of the middle ages found this to be true, and our school teachers of former generations, who were their direct descendants, for a time kept up this wise tradition. The desk top

should be made in two independent halves, the upper or farther edges so constructed that either may be raised, thus varying the pitch from the minimum of 30° to a maximum of 45° and thus adapted to reading or writing at pleasure. Thus made, the right-hand leaf would be the only one used for writing. All pupils should, of course, have desk and chair so adapted to their height that the book or paper would be at 14 inches from the eye when looking down upon it with a visual axis at an angle or inclination not greater than 150° or 155° . The visual axis at about 150° should approximately form a right angle with the inclination of the desk leaf at about 30° . (According to the oculist's trial frame, and as figured in illustration, the desk top would be at 145° and the visual axis at 35° .)

The Relation of Occidental and Oriental Writing Postures and Methods to Spinal Curvature.—In China and Japan the habits and methods of writing present throughout most noteworthy contrasts to those customary with us. The particulars may be briefly epitomized as follows:



FIG. 13—Oriental method of holding the writing brush, giving an unobstructed view of the writing-field.

1

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1. The writing begins at the upper right-hand corner of the paper, giving an evident advantage in seeing the writing field or letters which are being formed, and especially with the right or dominant eye.

2. The lines of writing proceed from the top to the bottom of the page, thus again securing increased visibility of the writing-field.

3. There is thus no need and no practice of skewing the paper to secure unimpeded vision of the writing-field. The writing is naturally vertical.

4. The writing brush (corresponding to our pen and holder), is grasped from two to four inches from the brush tip (corresponding to our pen); it is held usually between the second and third fingers (instead of between the thumb and first finger as with us), and either upright or slanting away from the writing space, to the right, and not, as our children are instructed, with the holder pointing toward the right shoulder. (Fig. 13.) Each one of the methods of holding the brush aids decidedly, and collectively very powerfully, in keeping the writing space clearly in view of the vision of both eyes.

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It seems almost as if all these methods were consciously designed that the writing-field might be seen.

5. In addition, Japanese and Chinese friends tell me it is a habit of many to hold the paper with the left hand, in the air, and pitched at an angle of from 30° to 50° . I did not know of this custom until months after I had written advising a pitch of the leaf of the writing desk of 30° . A greater pitch than this would sometimes not permit the ink to flow freely from our steel pens. The medieval copyists used a pitch of 50° or over, and our modern draughtsmen and artists often do the same. Modern artists in painting and sketching secure the clear view of the field of work by setting their canvas nearly vertical and by holding the brush or pencil from three to ten inches from the point. There are more modern writers than we suspect who increase the extent of visibility of the writing-field by holding the pen between the first and second fingers, or by grasping the holder two or three inches from the pen-point, by turning the hand half upward, or by slanting the penholder to the right. But these are devices forbidden by teachers (and writing

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books), who have no perception of the simple reason why the so-called "incorrect" habits and postures are unconsciously chosen.

6. Whether we should imitate the Oriental methods described above, either in part or not, is at present not my concern. Their result is our one great desideratum—the preservation of the erect and hygienic posture during the writing act. There is little or no bending of the head to the left. If this functional right cervical curve, habitual in the Occidental posture, is the cause of the incipient spinal curves of our school children, it follows that there will be far less than 27 percent of Japanese and Chinese children showing such curves between the ages of seven and fourteen years. An orthopedic examination of the backs of a large number of the children of Oriental schools would yield interesting and critical results. A minor query would be as to the proportion of scoliotics among Occidental children blind from infancy.

That the approximation to the upright posture (not its absolute practice), lessens scoliosis, is apparently shown by the following statistics of examinations of school children:

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	Slant writers percent	Vertical writers percent
Nurnberg	34	15
Zürich	32	12
Munich	24	15
Furth	65	31
Wurzburg	28	8

The first column averages 30 percent, the second 16. But if the slanted style is accountable for twice as many scoliotics as the vertical, the vertical is still, apparently, responsible for one-half as many as the slant. It is, therefore, evident that the vertical style did not insure the vertical position of the head and body, or that some other cause is at work. If the true reason of malposition in writing had been understood, and the conception of its cure realized, the results and their suggestions would have differed and been of greater value. The above great differences found in different cities also exhibit an inexactitude which makes no one doubt the valuelessness of the methods employed.

The School Desk.—There is probably not a pupil's desk in the world constructed upon correct physiologic principles. Many approximate, but fail in one or more important particulars. This is because, with all of the inter-

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est, study, and invention which have been put into the work, with all that has been written concerning the vertical and slanted handwriting, there has been no understanding of the physiology of righthandedness and righteyedness, no comprehension of the optic problem which controls every posture and act. The wrong to the child began with the beginnings of pedagogy. Prior to this handwriting was usually vertical, because without a powerfully dominating necessity no adults, much less the shrewd monks, would have bent themselves to the left and skewed their vellum, tablet, or paper at the absurd angle now common with all writers. But when school teaching began it was, of course, in the houses or rooms of adults, and with their tables, benches, forms or stools. No one then dreamed of the peculiar child nature, not even the size of the child's body. Hence, he sat upon a bench or seat too low, or what amounts to the same thing, at a table too high for the height of his body, and at about the level of his sternum, neck, or chin. When compelled to write he could do nothing at the desk, except by placing his forearm, and even his elbow, upon the table. Let an adult try to write sitting at a

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flat table the height of his neck and he will realize the child's predicament. With the arm upon the table there can be no writing accomplished unless the head is canted to the left, the body also, the paper placed askew, the feet or one foot thrust out to lessen the strain and wrenching of the spine, the pen held at a related abnormal angle, and the hand gripping the holder in a distorted way. (Fig. 2.) All this, that the right eye may have an unimpeded view of the space in which the letters are being formed. Think of the millions of morbidly raised right shoulders, the millions of necks and backs thus wrenched, with all the resultant disease, and during the last 400 years! And still going on!

Most school desks are without lateral space to the right in which the paper may be placed opposite the right shoulder when the body and head are erect and squarely placed in front of the desk, and not as now in front of the face or chest. This lack of lateral space to the right has always been the unrealized need, and upon securing it the complete establishing of the vertical style of handwriting will depend, as also the rescue of the child from the bad post-

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ures and ill-health caused by the diabolic head-tilting, right-shoulder-elevating, eye-ruining, body-bending, pelvis-cramping, spine-twisting, scoliosis-provoking postures, which have come down to our times. It will be useless to demand of the child that he shall write vertically, sit vertically, place the paper squarely and not askew, and opposite the median line of the body. No human being can write in that way unless the penholder is held with the tip directed toward the northeast, or upper right corner of the paper (Fig. 9), or even toward the north, all sure to produce writer's cramp, or other evil results in a short time.* In former times, as we know, the children were crowded together side by side so that it was impossible to place

* Some time after these words were in type, a striking confirmation was found in an article published without any knowledge of my work. I quote the paragraph:

"One thing, however, has been much impressed upon me, and that is that those who are normally lefthanded and are taught to write with their right hand, suffer from writer's cramp much more readily than normally righthanded individuals. It would seem as though nature were taking her revenge for an interference with her original plan, for the man is right-brained and should not be compelled to use his right hand for a work requiring so much coördination as does writing." ("Some So-called Rheumatisms," J. J. Walsh, *Medical News*, February 18, 1905.)

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the paper opposite the righthand side of the body and keep the body and head erect. The high desk united to compel the arm to be rested upon the desk, the right side to be turned toward it, the left side away from it, the head and body bent to the left in order to gain a clear view of the writing space of the pen-point with the dominant eye. Even the flat desk or table co-operated to produce the resultant bad posture and the slanted chirography.

In all lefthanded writers the foregoing factors and results are reversed, and the writing is back handed, or slanted to the left. (Fig. 14.)

There has also been much error in the statements made as to the history of slanted handwriting. The superb *History of the Art of Writing*, by Dr. Henry Smith Williams, gives an illuminating series of examples which show that the slanted handwriting appeared much earlier than has been supposed. Despite the high-pitched slope of the desks of the professional and more learned scribes, and also notwithstanding the dictation of the original vertical engraved, etched, or painted patterns, the slanted style appears throughout the Middle Ages, as the necessary result of the writing



FIG. 14—All malpostures are reversed by left-handed writers, and, this particular patient gained a better view, in his habitual writing, by holding the penholder as pictured.

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posture consequent upon the flat table, etc. Even in A. D. 93, the letters of a Greek MS. plainly lean to the right, and in a cursive Latin imperial rescript of the Fifth Century the slope is 15° . In a grant to the Church of Ravenna of the Seventh Century, the right oblique slant is 10° or more, and even in Magna Charta all letters lean to the right somewhat. Examples of similar slanting are found in the handwriting of Michael Angelo, Macchiavelli, Ariosto, Tasso, Luther, Shakespeare, Bacon, Lope de Vega, Milton, Locke, Leibnitz, Johnson, etc. Montaigne, Spencer, Galileo, Corneille, Addison, Pope, Newton, Voltaire slanted their letters to about the same extent as is now customary. Dante, Piers Ploughman, and others, wrote the vertical hand. Goethe leaned his letters extremely, Schiller less so, while Tennyson's were nearly vertical. Thackeray's were absolutely upright. Of the signers of the American Declaration, only one is in vertical letters. Longfellow wrote a "backhand," and in a MS. of the Tenth Century the letters also lean to the left, as do MSS. of Henry II and Richard I. In King John's Charter the letters are generally upright, although many letters slant to the left,

especially lower case *d*, and capital *D*. Of course the best writers and penmen were usually intelligent, and wrote more nearly correctly, *i.e.*, vertically, while the writers of the lower and commercial classes illustrate the degeneracy which quickly overcame the cursive style of writing. In general, the older and more im-

The unanimous Dec

When in the course of
*of time among the powers of the earth, the separate and equal station to
 should declare the causes which impel them to the separation —
 with certain unalienable Rights, that among these are Life, Liberty
 flows from the consent of the governed; — That whenever any Form
 Government, laying its foundation on such principles and organ.*

FIG. 15—The older the style of writing, the more perpendicular or vertical the letters; the later and more cursive, the more slanted become the letters, even in the same document—*e. g.* The Declaration of Independence.

portant styles of headings, those in capitals, etc., were upright, while the less important and the body of the writing showed the inevitable leaning that came with crowding, and cursive writing. An instance of this is our own Declaration of Independence, a few lines of which next to each other I reproduce. (Fig. 15.)

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Malposture Not the Cause of Myopia.—In almost all the discussion as to school-desks, especially that originating in Europe, there is much said about the influence of malposture in producing myopia, and it is largely twaddle. The tremendous gathering of statistics and the thoughtless ascription of the truly tragic increase of myopia to malposture in study and writing are essentially wide of the mark. Some accidental, incidental, and subordinate influence is, indeed, to be ascribed to the malposture criticised. Kotelmann's pages concerning myopia are, for instance, wholly misleading, and utterly ignore the real cause—which is the noncorrection of ametropia, and especially of astigmatism. In Germany, the motherland of myopia, there is no scientific correction of ametropia. The very simplest and most fundamental conditions of accuracy are wilfully or ignorantly unnoticed, and the ocular, nervous, and nutritional systems are hopelessly ruined and by wholesale. With one splendid exception our American students of the subject have usually adopted the European blunder, and for a hundred years we shall doubtless have the empty echoings of the Euro-

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pean nonsense as to school desks and myopia.

In an article (published in the *Klin. Monatsbl. f. Augenheilkunde*, July, 1904, and translated in the *Annals of Ophthalmology*, January, 1905), Dr. Liebreich lends his authority to the error that myopia is caused by the combined action of too strong convergence and too great an accommodation tension, quoting the investigations of Cohen, Hersing, Seggel, and others. This inversion of cause and effect does not prevent the true statement that "through the too near approach of the head to the table, the normal curvature of the spinal column is increased and by simultaneous rotation of the head and body lateral curvature ensues." Of course, all such statements and explanations miss the causes of the cause which are the action of astigmatism in producing myopia, its effect in compelling parallelism of the axes of the astigmatism and of the written lines on the paper, and the more fundamental necessity of binocular vision of the writing-field. Scholder also says that myopia is produced by getting the eyes too near the paper, because, he says, the more the head and body are depressed and thus myopia is produced. But what is the *causa causans* he never

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asks. Why the skewing of the paper? In Scholder's table of the increase of scoliotics in the grades of the Lausanne schools he notes in an added column the increase of myopia, as follows:

	Scoliotics percent	Myopes percent
First grade	8.7	3.
Second grade	18.2	4.5
Third grade	19.2	5.2
Fourth grade	27.2	6.
Fifth grade	28.3	8.5
Sixth grade	32.4	13.7
Seventh grade	31.	19.4

If the author had scrutinizingly asked himself why the increase of scoliosis is suddenly stopped and decreased at about 14 years of age, and why the rate of myopia at the same time is suddenly increased, he might have seen a suggestion of the cause of myopia. In Dr. S. D. Risley's magnificent article (Norris and Oliver: "System of Diseases of the Eye," Vol. II.) there is a clear understanding and statement of the problem of myopia. Myopia is not due to the bad desk and bad posture, but to the bad or absent spectacles. (I differ from Dr. Risley in one minor point—the astigmatism is not only "the turnstile," but the path, road, and continu-

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ance of the road itself, which leads to the bog of myopia.) If every school trustee, pedagogue, physician, and hygienist would read every word of Dr. Risley's article five times a year, one of the greatest afflictions of mankind might be obviated. Unfortunately, it is buried from all but ophthalmologists, and the majority of these care too little for this revolutionizing truth.

The remarkable success of all the European investigations in not seeing the cause of myopia is a painful illustration of the difficulties in the way of scientific and medical progress. Jaeger, Ely, and Horstmann were approaching the true explanation, in their work leading to the measurements of the anteroposterior diameter of hyperopic and myopic eyes; by Arlt and Donders, the latter emphasizing the role of predisposition—that easy, old and still popular word to cover ignorance of the real and active pathogenic factor. Dobrowoesky and Erisman charged the accommodation with the production of myopia, while Förster thought it was due to convergence. Mauthner ascribes the leading role to spasm of the ciliary muscles, while Stilling threw the responsibility upon the obliques and the shape of the orbit—a view opposed by

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Schmidt-Rimpler and Seggel. Hasner and Weiss contended that myopia is caused by a too short optic nerve, and Schnabel and Herrnhaiser by a lessened resistance of the sclerotic. It remained for an American oculist to discover the true etiology which is to-day as much ignored by European oculists and school hygienists as if it had been made this morning instead of 38 years ago. In 1867, and again in 1871, Dr. John Green of St. Louis set forth the explanation, and a few years later Dr. S. D. Risley of Philadelphia demonstrated it by studies of school children's eyes in epoch-making papers, which, within the next generation or two may begin to make the epoch.

The Evils of Eyestrain.—In all of the foregoing there have been considered only the children, students, and writers who had eyes so near normality as regards ametropia that they had no severe eyestrain or morbid reflexes from use of the eyes in a natural way, or even in the unnatural ways begotten by morbid postures; but unnatural posture produces unnatural ocular function, and besides this, from 25 percent to 50 percent of all civilized persons have eyestrain or hurtful use of ametropic eyes. The

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amount of harm done the eyes, the neurologic mechanism, the digestive and assimilative systems depends upon three things: the kind and the degree of the ametropia; the amount of reading, and especially of writing, done; the susceptibility of the patient, the general vitality, intercurrent diseases, etc. It has been found that from 50 percent to 64 percent of school children are sickly or below a desirable norm of health. I do not think it is an exaggeration to say that the ills of 50 percent of these hygienically subnormal children and students are due to the morbid postures compelled by the present false methods of writing and reading. Of the remaining 50 percent, a full half are directly caused by the eyestrain of ametropic eyes. Headache, "weak eyes," migraine, anorexia, dyspepsia, and many types of denutrition, spinal curvature, insomnia, "nervousness," many cases of chorea and epilepsy, despondency and frequent psychic disorders, truancy, immorality, etc., almost any form or kind of functional disease—all these, and the denutrition that fallows the ground for the incoming of infectious and terminal diseases—all of these are, or may be, the clear consequences

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of eyestrain. Only proper and scientific spectacles can extinguish these evils. But without glasses they are tremendously increased and intensified by the morbidities of posture engendered by the present school-desks and methods of writing and reading. A revolution is demanded by an enlightened hygiene in school furniture and methods of writing and study. It is the most profound and crying reform of the day, a matter of national and evolutionary importance almost overtopping all others.

Read the clinical biographies of the great sufferers from eyestrain, and note how intolerable and impossible writing becomes. A thousand quotations from their biographies and letters might be made showing that suffering of the most varied and subtle kinds follows directly upon use of the eyes especially in writing, and is at once relieved with cessation of writing and reading. The abnormal and morbid postures caused by nonunderstanding of the optic problems in writing add enormously to the pre-existing and attendant eyestrain.

CHAPTER VI.

THE PATHOLOGIC RESULTS OF RIGHTEYEDNESS AND LEFTEYEDNESS.*

A LITTLE observation and a few tests will show that, with some exceptions, to be noted later, the righthanded person is also righteyed; and the lefthanded is lefteyed. That is to say, there is, in the righthanded, the same habitual and unconscious choice of the image of the right eye for the more expert and important tasks, just as the right hand is chosen for those functions in skilled work. A righthanded hunter places his gun against the right shoulder because he can sight it with the right better than the left eye. The righthanded person, in playing the violin, violoncello, etc., is forced to use the left hand for the more expert task, because he thus sees the fingers and the neck of the instrument without foreshortening and better than he could if the fingering were done with the right hand. All actions, in fact, are de-

* American Ophthalmological Society, 1904; *Ophthalmology*, October, 1904; "Biographic Clinics," Vol. iii.

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terminated by the fundamental necessity that accurate vision shall precede all action, and vision is more accurate with the habitually exercised eye, just as manual function is more expert and reliable with the hand most exercised in a special kind of work.

A little closer observation soon demonstrates that not only is the righthanded also righteyed, but that he is usually rightfooted, and righteared. This is equivalent to saying that a person is either dextroexpert, generally, as to ear, eye, hand, and foot, or else he is sinistroexpert. There must manifestly be a unity in the co-ordinations of all acts, and such co-ordinations would evidently be better with a habitual one-sided similarity of execution running through all kinds of action, so that there would be no indecision in rapid and dangerous acts. The unity and the resultant promptness and accuracy of all motions is thus enhanced by a synchronous dextroexpertness or sinistroexpertness. The mixed type, illustrated by the so-called ambidextrous, would place the organism at a wretched disadvantage in the struggle for existence, and in the social struggle of the highest types of civilized life.

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become of exceptional interest to the ophthalmologist. That these pathologic results exist I have no doubt, and have repeatedly demonstrated in the persons of actual patients. I suspect that they exist in at least ten percent of all patients, and no case whatever can be treated wholly irrespective of the fact of righteyed or lefteyed function.

For purposes of naming and clarifying the ideas to be presented, let us call the right eye of righthanded persons, and the left eye of lefthanded persons, the dominant eye. The caution must be emphasized that the hand which does the writing unconsciously or preferentially dictates the location of the speech-center, and the true condition of righthandedness or lefthandedness.

It hardly needs the saying that the accidents of ocular diseases, keratitis, fundus lesions, cataract, high ametropia, heterophoria, amblyopia, etc., may put out of function, or threaten to do so, the primary—that is, the naturally, logically and neurologically—dominant eye, and thus the eye of the other side must be used as a makeshift and educated to become the secondarily dominant one. The older the age at

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which this occurs the greater the difficulty, the more of a tragedy will it be to the patient. There arise a hundred problems. I shall here allude, and most briefly, to but a few of these:

1. In all operative procedures there should be an exceptional striving to save the dominant eye. I do not believe in operations for this purpose, but if only one eye can be straightened and made functional in strabismus, by all odds let it be the dominant one. The strabismus of a naturally dominant eye will be more easily cured than that of the nondominant one. In double convergent squint the dominant eye should be the one first chosen to save. In certain cases of cataract extraction a similar rule should be followed.

2. In inflammatory diseases there should be the same solicitude, when choice, as frequently, is possible, to preserve the best function in the dominant eye.

3. The supreme value of the dominant eye makes it highly important that ametropia shall be corrected at the earliest day and year possible. Every month that amblyopia, heterophoria, or strabismus increases in that eye, makes the life history and struggle of that child

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a different and a more difficult one. Righthandedness, or its opposite, is pronounced in children of less than a year, and the location of the speech-center is being fixed rapidly, and often unchangeably, at two and three years of age.

4. If saving of the naturally dominant eye is impossible in the young child, and its fellow must be secondarily educated into dominancy, it becomes a question if the child should not also be taught to write, eat, etc., with the corresponding hand.

5. In the adult the dominant eye I have found will preserve its dominancy despite a considerably higher degree of amblyopia, ametropia, etc., than that of its fellow. But it is evident that there must be a limit. I doubt if the naturally dominant eye would retain its dominancy if it had, say, an acuteness of only 20/50 while the vision of the other was normal. This fact arouses a number of queries in the mind of the refractionist. One of these would refer to the inadvisability of giving the nondominant eye a greatly superior acuteness of vision by means of glasses. In an adult such a sudden change, even reversal, in the habits of part of a lifetime

might be brought about that the spectacles would not be tolerated, and failures of varied kinds ensue. The patient would then have a life handicap that would greatly lessen his personal validity and happiness.

6. An axis of astigmatism in the dominant eye from 10° to 20° to either side of 90° or 180° , while the axis in the fellow eye remains normal or unsymmetric, produces head-tilting; symmetric axes produce no head-tilting. In the few months after I discovered this law I found in the ordinary run of office practice over 30 cases of head-tilting. The stupid error I had made all my life was to allow these patients to cant the head during the refraction testing. In this way I had failed to find how large is the number of righthanded patients who have axes of astigmatism of the right eye from 10° to 20° to one side of 90° or 180° . And never before this had I thought of the necessity of inquiring as to righthandedness in patients having these slightly unsymmetric axes of astigmatism. It is evident that an axis in the dominant eye only 5° to one side of 90° or 180° would hardly produce a noticeable tilt of the head, or might possibly be compensated for by the rotation of

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the eyeball itself. It is possible that some types of heterophoria, and especially cyclophoria, may be explained as arising from this compensation of the ocular structures instead of producing the tilt or cant of the head. It also seems possible that this compensatory twist of the eyeball in the orbit may possibly cause a compensatory twist of the optic nerve, and perhaps certain other diseases of the papilla and retina. After prescription of proper correcting glasses it would be natural to find before long a secondary change of axis resulting from the rectification of the abnormal head-tilt, or ocular twist. Such patients must be kept under continuous and repeated observation.

If the axis of astigmatism of the dominant eye is about 75° or 165° , it is evident that, if the nondominant eye is unsymmetric, the head must be tilted to the right in order to bring the false axis into line with the vertical lines of print, trees, houses, wall paper, doors, etc.

If the axis of astigmatism of the dominant eye is about 105° or 15° , compensatory tilt of the head must be to the left. Greater variations of the axis than 20° would hardly be compensated for by head-tilting, but would either

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produce amblyopia, a transfer of dominancy to the other eye, or else some other pathologic consequence equally harmful to action and life. The axis of the largest number of head-tilters is 75° in the right eye, and thus the majority tilt the head to the right.

7. Among the 30 or more head-tilters I have found, in the few months mentioned, about a dozen with resultant spinal curvature or scoliosis. The fact was usually unsuspected by the patient, the parent, and the attending general physician. I sometimes had difficulty in getting consent that an expert orthopedic surgeon should verify the diagnosis. A report of these cases, the nature of the compensatory spinal curvature, and the cure by glasses alone, or by glasses and orthopedic help, will be published later. It is needless to add that the method of production of scoliosis resulting from an enforced and habitual abnormal position of the head is well understood by orthopedic surgeons. Habitual carrying forward, for instance, of the hearing ear in case of unilateral deafness will result in scoliosis. There are undoubtedly thousands of children with curved spinal columns in the United States whose spinal disease

is due to a slightly aberrant axis of astigmatism.

8. An ametropia in the nondominant eye which tends to throw it out of function is much more likely to result in malfunction, nonfunction, and disease of that eye than would be the case in the dominant eye. Many practical suggestions and rules result from this fact both in refraction work and in the management of inflammatory diseases. In amblyopiatrics, for instance, it is perhaps as well not to strive to give the nondominant eye an exceptional, or even an equal, acuteness of vision. Nature will not respond to the attempt so willingly as in a similar attempt with the dominant eye.

9. The failure to diagnose the unsymmetric variation of axis of the dominant eye will, of course, result in the noncure of the reflexes which are caused by eyestrain. This is so well established that it may serve as a reason for re-examination of the cases in which, in the past, there has not been perfect relief of patients with general ill health, migraine, dyspepsia, headache, neurasthenia, insomnia, melancholy, etc., probably due to eyestrain. Not seldom the change of axis found to exist when the refraction test is made with the head accurately erect

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will at once bring astonishing and brilliant relief in many forms of inveterate systemic functional disease.*

POSTSCRIPT.

After the foregoing paper had been read at Atlantic City, Dr. Peter N. Callan said to me that the suggestion of righteyedness had also come to him, and he had asked the question in the *Medical Record* of April 2, 1881. Confirmation of the fact had been found in the examination of the records of more than 1,000 of the private patients of Dr. H. D. Noyes in whom each eye had been carefully examined and the vision and refraction noted. The general results were that when myopia existed there

* A corollary of the discovery of the cause of so many cases of tilted heads is suggested. Beside the thousand vertical and horizontal objects that demand relief of astigmatism, or its placing at axes 90° or 180° , the predominant cause in civilization is the shape of the letters of the printed page. As a rule, these are made up chiefly of lines at axis 90° , supplemented by a few at 180° , and a less number of curves and of oblique axes, at about 60° or 70° , or, conversely, at 120° or 130° . It is these last which should be eliminated when it is possible, and in all but a few letters this is possible, the exceptions (K, V, X, Z) being relatively unimportant. The lower case of small letters could be modified in shape to correspond to these. The lesson as to vertical and slanted handwriting at school is equally plain.

was a higher degree in the right than in the left eye, and when hyperopia was present there was a less degree in the right than in the left. In the hyperopic cases the vision was more acute in the right than in the left, and in the myopic the vision was almost the same in each eye, taking all degrees into consideration. Dr. Callan drew the conclusion "that with binocular vision we use one eye more than its fellow—that one being generally the right eye." This quick confirmation of the theory of dextrorcularity was unexpected, and suggests a number of valuable and practical rules in refraction work, in the care of the eyes of school children, students, etc.

There are indirectly further proofs of the theory to be found in the ingenious and instructive paper of Dr. Wheelock Rider, on "Unilateral Winking," published in *Transactions of the American Ophthalmological Society*, 1898, to which my attention was kindly directed by the author, in the discussion of my paper, and which had also escaped my notice.

CHAPTER VII.

A PATIENT'S STRUGGLE FOR RIGHT-EYE FUNCTION.*

IN the May, 1906, issue of *American Medicine* I reported the case of a patient, a physician, who had suffered atrociously for 30 years. His single disease had been eyestrain, at least up to the time when insane surgery had not added its possible of injury and insult to the man's already overgreat misery. This outrage consisted in tearing out the four healthy trunks of the infraorbital and supraorbital nerves. So blunderful was the operator, *quâ* surgeon, that he had destroyed the function of the levator, the motor nerve raising the right eyelid, and the man had complete ptosis of this lid. As I suggested in my former report, one could hope for little relief when terrible eyestrain and surgery had done their worst. I expected to do so little toward cure, or even relief, that I thought the case history at an end and therefore reported it as if complete. And, as I said, one of the most hopeless of conditions had been

* *American Medicine*, April, 1907.

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needlessly added in the paralytic ptosis of the right or dominant eye. This, in a righthanded man of 38, must prove a great calamity by suddenly throwing into the adult mechanism of dextroexpertness the morbid faculty of absolute lefteyedness.

Following the wearing of spectacles correcting the patient's ametropia there was such great relief of the pain, neuralgia, etc., that there was danger of forgetting the morbid left-eyedness caused by the ptosis. Within a short time the complaints began returning, but they were noticeably vague. Every former one had greatly lessened or disappeared but there was pain in the antrum and other indefinite trouble seemingly as unendurable as before. I begged that the long journey to visit me should again be made.

When the patient came it was soon apparent that the chief source of the present afflictions was that the right eye was shut out from its normal function. The perfect proofs of this were the following:

1. Although there was only a narrow slit between the lids a glimpse could be obtained of the book or of more distant objects by throwing

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the head far backward; the patient was thus ignoring the sound left eye whose vision was perfect, and he was going about with his head bent back in an extreme and torturing manner in order to gain a glimpse of objects with the preferred right eye.

2. To gain some relief from the suffering in the neck, etc., from this most unnatural posture, the patient had to bend the head forward frequently, and thus there was an incessant rocking of the head far backward and then forward.

3. Vision was decreasing in acuteness in both eyes, and both for distant objects and in reading. Halos and dark spots in the field of vision were appearing, and worrying the patient, ocularly and mentally.

4. The pupil of the left eye was becoming continuously dilated and only partly responsive to light and accommodation.

5. Both eyes, especially as to lids and conjunctiva were becoming morbidly congested and even inflamed.

6. Great drowsiness, complaints of being tired out, etc., were growing worse. The mind was incapable of work, and there was a dull and lethargic condition very noticeable.

7. The morbid efforts to raise the right lid were wearisome and irritating.

8. Most important of all was the continual shutting of the normal left eye and with morbid effort, reading with the right eye.

There was no doubt in my mind that the struggle for righteyedness was at the bottom of all the mischief and that unless the right eye could be got into function, life-wreck was imminent. The traumatic ptosis must be done away with!

One of our most experienced ophthalmic surgeons was consulted, and after thorough study he refused to operate. He probably had no sympathy with my theory of righteyedness. He did not see why the left eye should not take up the sole function of vision, feared the operation might not be successful, etc. As I believed the man's life depended upon re-establishing the function of the right eye, I took the patient to another surgeon, Dr. Geo. C. Harlan, of Philadelphia. He consented to operate. Within a week the dominancy of the function of the right eye was restored, and at once all the symptoms enumerated above disappeared. From the last letter dated March 11, 1907, I quote:

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"I have been more busy than in years, and am in the best condition. I have no trouble now, and read all that I have a chance to. The lid is up for all practical purposes, but for long distance vision I tilt the head backward a little. If the other eye were gone I could get on well. There are no spots or halos before the eyes, no cloudiness, etc. I have no pain except from colds, or from sneezing. The antrum trouble is well. I feel like a king and enjoy my work. You have been the best friend I ever had. I am interested in your fight. I am going to read a paper on eyestrain before the next meeting of our State Medical Society."

CHAPTER VIII.

THE NOMENCLATURE OF DEXTRAL, SINISTRAL, AND ATTENTIONAL ORGANS AND FUNCTIONS.*

IN the *Popular Science Monthly*, August, 1904 (republished in *Biographic Clinics*, Vol. III.), I made some suggestions as to the nomenclature of the organs and functions pertaining to righthandedness, lefthandedness, etc. After a more extended study and experience of the subject I recognize that I made some errors and more omissions, and these I may now correct. The terms *righthanded* and *lefthanded* are so firmly fixed in the language, and so recognized as expressing the unconscious choice and superior expertness of one or the other hand for certain tasks, that it is useless to attempt putting them aside for more accurate words. Established usage and habit make language and govern the world. "Right-handed," "left-handed," etc., imply nothing of expertness, etc., literally, but usage has put such meanings into them. Terms merely localizing the organs

* *Popular Science Monthly*, November 1, 1907.

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without added significance must therefore be devised, *e.g.*, *dextral*, *sinistral*, *dextromanual*, *dextroocular*, and all the rest. To extend the idea of expertness to the corresponding organs, *righteyed*, *lefteyed*, *rightfooted*, *righteared*, etc., may be used after the analogy of *righthanded*. The words *ambidextral* and *ambidexterity* should never be used by sensible persons. No one has yet existed with two dextral hands; no lefthanded person has ever been trained to have an equal proficiency or expertness of each hand for all tasks; it would be most undesirable and wasteful of life to have such equal expertness; all or most such attempted training results in unhappiness, confusion, inexpertness and disease. The righthanded, according to the crazy theory, should be trained to an equal and ludicrous sinistromanual expertness, etc.; the violinist should bow or finger equally expertly with each hand; the pianist play upon a reversed keyboard, the base notes to the right, half the time; soldiers should carry their guns and swords half the time in the left hand, step off with the right foot first on alternate days; and all sewing, writing, use of the knife and

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fork, handshaking, etc., done alternately with the sinistral and the dextral hands, etc.

As to righteyedness, lefteyedness, etc., there is a world of new facts coming to light of profound importance, medically, surgically, socially, and especially to the person abnormal in these respects. In practical ophthalmology, "dominance" of the dextral eye in the righthanded, and the preservation of it, or re-establishment of it when lost (*vice versa* in the case of the lefthanded), is of vast import, possibly to the life of many individuals. With divided or alternate dominance one of my patients was constantly making mistakes, confused, running into objects, steering his automobile into collisions, etc. (The tests are many and easily made: For instance, looking through the held-up pencil or finger at the opposite wall, an image, one image, of the pencil is seen by the dominant eye—the dextral, of course, normally, in the righthanded, the sinistral in the lefthanded. If the dextral is the dominant eye, then by putting something over the left, the image will not be displaced; if the dextral eye is shut off, the image of the pencil will "jump" to the right. If the sinistral is the dominant

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eye, the reverse will take place.) If two images are seen, then the person has divided dominance or equidominance, and he is a patient, having confusions of mind and action which may cause accidents at any time, and which must decidedly abnormalize him in many ways. Probably equidominance is a half-way stage of the change from normal to reversed dominancy. It would be better that the righthanded should have the sinistral eye dominant (*vice versa* in the left-handed) than that he should have equidominance. I have had four patients reaching middle adult life who used one hyperopic eye solely for distance-vision (*i.e.*, for objects over about two feet away), and the other myopic eye solely for all vision in reading, writing, etc. Of course the hyperopic eye in such cases (as in one of my patients), although the left (in a righthanded person), must become the dominant eye, because dominance has existence and use only in distance-seeing.

The necessity for new terms to designate the states and functions of attention comes to view in the fact that civilization is creating a new sort of consciousness and attention. The old psychology considered that attention or con-

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sciousness was to be likened to the passing of single grains of sand through the constriction of the hour-glass. That view was largely true, because I believe that attention is genetically and chiefly a product of vision, and that vision of the older and simpler type of eye and mind was indeed that of a continuous linear stream of single images (objects) focused one after another at the macula. But the modern mind (of the great and rapid reader, of the musician, and of men in many trades and callings) is learning to see and know and use many synchronous and co-ordinated images, and streams of images, both at and away from the macula. There is a growth and extension of the macular region and of its imaging, one may say, or the power of attention and consciousness is growing more and more able to receive, interpret and control the many streams (which is the same thing as the enlarged stream of sand grains), of images focused in and about the macula. Thus mental largeness, power, attention and consciousness are growing at a great rate in our complex and differentiating civilization, and the old nomenclature based upon the hour-glass comparison is no longer adequate. Especially

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if is added the marvelous power of the ear, as in the musician, to receive, encompass and be conscious of ten, fifty, or even a hundred streams of discrete synchronous tones. The following terms may therefore be found useful:

Righthanded.—Preferring the dextral hand for the more expert or intellectual tasks. Whence *righthandedness*.

Lefthanded.—Preferring the sinistral hand for the same tasks. Whence *lefthandedness*.

Righteyed.—Preferring the dextral eye as the dominant one.

Lefteyed.—Preferring the sinistral eye as the dominant one.

Righteared.—Preferring the dextral ear as the one with which to hear sounds.

Lefteared.—Preferring the sinistral ear with which to hear.

Rightfooted.—Choosing the dextral foot as the one to guide and base action, from which to spring in beginning to march, in spading, etc. “Step off with the left foot forward.”

Leftfooted.—The power is furnished and governed by the sinistral foot.

Right.—Moral, good, etc.

Sinister.—Unlucky, gloomy, etc.

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Dexterity.—Expertness, agility, etc.

Dextrous.—Expert, agile, etc.

Because of popular usage, the four preceding may retain their vague significance in common speech, but not in science.

Dextral.—Pertaining to the organs on the right side of the body, regardless of expertness, preference, etc. When facing east the dextral hand is on the south side, the sinistral on the north side.

Sinistral.—Pertaining to the organs on the left side of the body, regardless of special preference, expertness, etc.

Dextrality, Sinistrality.—The corresponding abstract qualities, regardless of expertness, etc.

Dextrad, Sinistrad.—Toward the dextral or sinistral side of the body, respectively.

Dextromanual, Sinistromanual.—Pertaining, respectively, to the dextral or to the sinistral hand without regard to expertness, etc.

Dextrocular, Sinistrocular.—Pertaining to the eye on the dextral side, or the sinistral side, respectively, regardless of expertness, etc.

Dextropedal, Sinistropedal.—Pertaining to the feet, in the same way.

Dextraural, Sinistraural.—Pertaining to the ears, in the same way.

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Dextrocerebral, Sinistrocerebral.—Located in the right, or the left, cerebral hemisphere, respectively.

Ambidextral, Ambidexterity.—Words without significance, or existence in fact, “ghost-words,” which should never be used.

Dominant Eye.—The eye which is unconsciously and preferentially chosen to guide decision and action.

Divided Dominance, or Equidominant Eyes.—With shared or equal dominance.

Alternating Dominance of the Eyes.—Dominance of one eye at one time or for one function, alternating with that of the fellow for another time or function.

Reversed Dominance.—The left, because of ametropia, disease, operation, etc., of the right, becoming the dominant eye in the righthanded; or vice versa in the case of the lefthanded.

Dextroexpertness.—Conjoint and superior expertness of the dextral sensory and muscular organs of the body; the union of righthandedness, righteyedness, rightearedness and rightfootedness. The innervational centers of the more expert organs are located in the left side of the brain.

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Sinistroexpertness.—Conjoint and superior expertness of the sinistral sensory and muscular organs of the body; the union of left-handedness, lefteyedness, lefttearedness, and leftfootedness. The innervational centers of the more expert organs are located in the right half-brain.

Mixed Dextrosinistral Expertness.—Some of the centers of the more expert organs in conjoint action are located in one, and some in the opposite half-brain. What was once meant by the really meaningless term “ambidexterity,” as applied only to the hands.

Trailing Hand, “The Trailer.”—In synchronous writing of both hands, that upon which the attention, visual or central, is not fixed.

Visual Attention.—That existing when the eyes consciously observe a fixed or moving object; during the act central or mental attention is fused with it.

Central Attention.—The “imagination,” or mental remaking, of the image, by the mind or central mechanism when the peripheral visual attention is abrogated.

Single-stream Visual Attention.—That form

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of visual attention existing when the eyes follow a linear concatenation of single or unitary macular images to the exclusion of all others.

Single-stream Central Visual Attention.—That when the central visual attention, without objectively forming images, follows the passing of imagined single or unitary images in single file.

Multiple Synchronous Visual Attention.—That when the attention recognizes two or more discrete sets of retinal images at the same time—as when the musician reads several staves of music-notes, observes key-boards and pedals, the indications as to stops, tempo, expression, etc.

Multiple Synchronous Central Visual Attention.—The imagining or mental reproduction of multiple synchronous visual trains without the objectively formed images.

Single-stream Auditory Attention.—That when a monotone, a sound, or concatenation of single notes or sounds, is listened to, exclusive of others.

Single-stream Central Auditory Attention.—That without the objective audition.

Multiple Synchronous Auditory Attention.—

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Two or more synchronous tones or sounds, or lines of such tones or sounds, are recognized by consciousness, as in the case of the orchestra-leader who gives attention to a large number.

Compound Synchronous Attention.—In this the consciousness recognizes and correlates or combines multiple streams of synchronous and diverse stimuli, visual, auditory, etc. Illustrated by expert telegraphers, locomotive engineers, musicians, etc., seeing, hearing and feeling consciously at one instant.

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